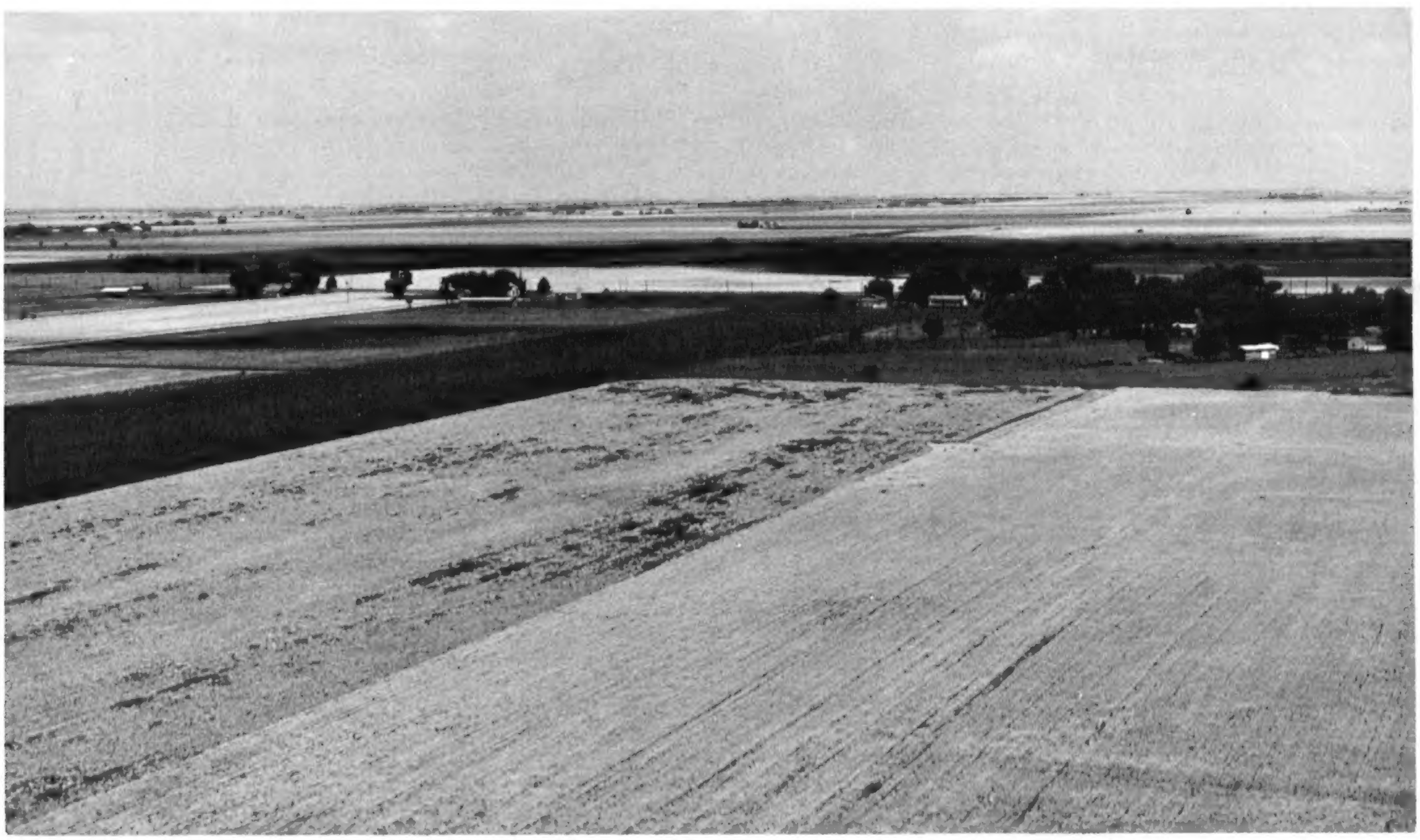
SOIL SURVEY
KAY COUNTY
Oklahoma



UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
In cooperation with
OKLAHOMA AGRICULTURAL EXPERIMENT STATION

Issued December 1967

Major fieldwork for this soil survey was done in the period 1957-63. Soil names and descriptions were approved in 1965. Unless otherwise indicated, statements in this publication refer to conditions in the county in 1963. This survey was made cooperatively by the Soil Conservation Service and the Oklahoma Agricultural Experiment Station as part of the technical assistance furnished to the Western Kay County and the Arkansas River-Kay County Soil and Water Conservation Districts.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY of Kay County, Okla., contains information that can be applied in managing farms, ranches, and woodlands; in selecting sites for roads, ponds, buildings, or other structures; and in appraising the value of tracts of land for agriculture, industry, or recreation.

Locating Soils

All the soils of Kay County are shown on the detailed map at the back of this survey. This map consists of many sheets that are made from aerial photographs. Each sheet is numbered to correspond with numbers shown on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units" can be used to find information in the soil survey. This guide lists all of the soils of the county in alphabetic order by map symbol. It shows the page where each kind of soil is described, and also the page for the capability unit and range site.

Individual colored maps showing the relative suitability or limitations of soils for many specific purposes can be developed by using the soil map and information in the text. Interpretations not included in the text can be developed by grouping the soils according to their suitability or limitations for a particular use. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils in the soil descriptions and in the discussions of the capability units, range sites, and woodland suitability groups.

Foresters and others can refer to the section "Management of Woodland for Windbreaks and Post Lots," where the soils of the county are grouped according to their suitability for trees.

Game managers, sportsmen, and others concerned with wildlife will find information about soils and wildlife in the section "Wildlife and Fish."

Ranchers and others interested in range can find, under "Management of Range," groupings of the soils according to their suitability for range, and also the plants that grow on each range site.

Engineers and builders will find under "Use of Soils in Engineering" tables that give estimates of engineering properties of the soils in the county and that name soil features that affect engineering practices and structures.

Scientists and others can read about how the soils were formed and how they are classified in the section "How Soils Are Formed and Classified."

Students, teachers, and others will find information about soils and their management in various parts of the text.

Newcomers to Kay County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Nature of the County," which gives additional information about the county.

Cover picture: An area of Waurika silt loam, west of Ponca City.

U.S. GOVERNMENT PRINTING OFFICE: 1967

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Contents

NOTICE TO LIBRARIANS

Series year and series number are no longer shown on soil surveys. See explanation on the next page.

Issued December 1967

EXPLANATION

Series Year and Series Number

Series year and number were dropped from all soil surveys sent to the printer after December 31, 1965. Many surveys, however, were then at such advanced stage of printing that it was not feasible to remove series year and number. Consequently, the last issues bearing series year and number will be as follows:

Series 1957, No. 23, Las Vegas and Eldorado Valleys Area, Nev.
Series 1958, No. 34, Grand Traverse County, Mich.
Series 1959, No. 42, Judith Basin Area, Mont.
Series 1960, No. 31, Elbert County, Colo. (Eastern Part).
Series 1961, No. 42, Camden County, N.J.
Series 1962, No. 13, Chicot County, Ark.
Series 1963, No. 1, Tippah County, Miss.

Series numbers will be consecutive in each series year, up to and including the numbers shown in the foregoing list. The soil survey for Tippah County, Miss., will be the last to have a series year and series number.

SOIL SURVEY OF KAY COUNTY, OKLAHOMA

FIELDWORK BY JAMES R. CULVER, WILLIAM R. BAIN, AND BERYL G. BAGGETT, SOIL CONSERVATION SERVICE

REPORT BY JAMES R. CULVER

UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE OKLAHOMA AGRICULTURAL EXPERIMENT STATION

KAY COUNTY is on the northern border of Oklahoma adjacent to Kansas (fig. 1). The county has a total area of 604,160 acres. Newkirk, the county seat, is in the north-central part of the county.

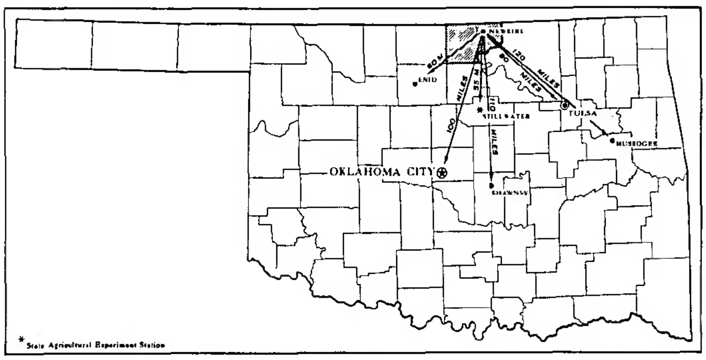

Figure 1.—**Location of Kay County in Oklahoma.**

About 84 percent of this dominantly agricultural county is arable. The main enterprises are the growing of small grains, mainly winter wheat, and the raising of livestock. Crops are extensive in the central and western parts of the county, range and pasture are dominant in the eastern part.

The uplands in the central and western parts of the county are generally nearly level or gently sloping. The more sloping areas are near the natural drainageways. Nearly all soils of the uplands in this area are deep, and many of them, such as the Tabler, Bethany, and Kirkland soils, have a clay subsoil. Norge and Vanoss soils are more loamy, and Vernon and Owens are shallow over clay or shale. In the eastern part of the county, the landscape is more broken than that in the central and western parts and limestone escarpments are prominent. The soils are deep to very shallow and have the strong granular structure that is characteristic of many soils developed from limestone. The deep or moderately deep Newtonia, Labette, and Summit soils occur with the very shallow Sogn soils. Pratt, Eufaula, and other sandy soils on uplands are not extensive in this county.

Soils of the bottom lands make up about 22 percent of the county. The wide bottom lands along the Salt Fork Arkansas and the Chikaskia Rivers are well suited to intensive farming. The principal soils on these bottom lands are the Reinach, Port, Brewer, McLain, and Yahola. The dark-colored Kaw soils are extensive along small streams throughout the county. Dale, Humbarger, and Carr are dominant on the flood plains of the Arkansas River.

General Soil Map

The general soil map at the back of this soil survey shows the eight general soil areas, or soil associations, in Kay County. In these general areas, the individual soils are not shown. Each soil association is identified by a different color and number and is named for its dominant soils and its physiographic features.

A soil association is made up of soils that occur in a characteristic and recurring pattern. This pattern is related to the kind of the parent materials and the relief, or lay of the land. Although several soils generally occur in an association, the association is named for the dominant soils.

The general soil map and the discussion of the soil associations are intended only as general guides for those desiring soil information. They will provide information valuable in comparing different parts of the county, in locating large areas suitable for some particular type of agriculture, in making an economic study, or in obtaining information for other broad uses of the soils. The general soil map, however, shows only broad patterns and relationships; it is not suitable for planning the management of a farm or field.

Of the eight soil associations in Kay County, two are on bottom lands. The rest are on uplands. The two associations on bottom lands are distinguished from each other by the texture of their soils. More detailed information about the individual soils in each association can be obtained by studying the detailed soil map and by reading the section "Descriptions of the Soils."

1. Kaw-Brewer-Reinach-Lela Association

Deep, loamy to clayey soils

This soil association consists of the highly productive bottom lands along the rivers and other large streams in the county. Parts of the association are the nearly level strips, 1 to 2 miles wide, along the Chikaskia River and the Salt Fork Arkansas River. This association occupies 105,485 acres, or about 17 percent of the county.

The Kaw soils, which make up 23 percent of the association, are on the flood plains of small streams

throughout the county. These deep, granular soils formed in recently deposited, dark-colored sediments. The dark-colored Brewer soils are mainly along the Chikaskia River on bottom lands that are seldom flooded. They have a clay subsoil but are moderately well drained.

The deep, friable Reinach soils formed in loamy sediments on high bottoms of the Chikaskia River and the Salt Fork Arkansas River. Lela soils, which are in level to depressional areas associated with the Brewer soils, have a black, light clay surface layer and a subsoil of massive clay that absorbs water very slowly. Lela soils are the finest textured soils on bottom land in the county and are difficult to farm. They are normally in large areas, chiefly along Birds Nest Creek and on second bottoms along the Chikaskia River. About 14 percent of the association is Brewer soils, 14 percent is Reinach soils, and 13 percent is Lela soils.

Also in this association are the Port, McLain, Dale, and Miller soils and Broken alluvial land. Port soils make up a considerable part of the association, but the other soils are minor. The Port soils are between the loamy Reinach soils and the more clayey Brewer soils. Port soils are deep and loamy but may have a layer of clayey material in the subsoil. McLain soils are along the Salt Fork Arkansas River on bottom lands that are seldom flooded. They have a dark reddish-brown clay to clay loam subsoil. The Dale soils are in fairly high positions along the Arkansas River and are seldom flooded. The Miller soils, which lie in depressions, are clayey, reddish brown, calcareous, and somewhat poorly drained. Broken alluvial land occurs where the rivers and smaller streams have cut out deep, wide channels. It is used for pasture and habitat for wildlife.

The soils in this association are choice for farming. Except for small, inaccessible areas along rivers and smaller streams, all of this association is cultivated. Crop yields on the loamy soils are excellent, but inadequate drainage reduces yields on the Lela clay. In this association flooding damages crops only slightly, and some areas, such as those south of Tonkawa, are never flooded.

2. Yahola-Lincoln Association

Deep, sandy soils

This soil association consists of sandy, flooded soils on bottom lands of the Arkansas River and the Salt Fork Arkansas River. These bottom lands are generally nearly level to slightly wavy, but there are a few scattered dunes. This association occupies 28,155 acres, or about 5 percent of the county.

The Yahola soils occur mainly on first bottoms of the Salt Fork Arkansas River. They make up about 26 percent of the association. These soils are brown to reddish brown and sandy. They formed in stratified, calcareous loamy sand to fine sandy loam sediments of the Permian redbeds. Yahola soils are occasionally flooded.

Lincoln soils consist of stratified, calcareous sandy material. They occupy slightly wavy areas next to the Arkansas River and are frequently flooded. These soils formed in stratified recent alluvium and occupy about 5 percent of the association.

Also in this association are the Carr, Humbarger, and Miller soils and Sand dunes, Lincoln material. The Carr and Humbarger soils formed in sandy to loamy stratified alluvium and are subject to damaging floods. Carr soils have a grayish-brown to brown, calcareous fine sandy loam surface layer. They occupy low, occasionally flooded areas near the channel of the Arkansas River. Humbarger soils occur farther back from the river and are more loamy than Carr soils. The reddish-brown, clayey, somewhat poorly drained Miller soils occur in small areas within the larger areas of Yahola soils. Sand dunes, Lincoln material, which make up 9 percent of this association, are adjacent to the Yahola, Carr, and Lincoln soils. These stabilized dunes rise 5 to 15 feet above the flood plains.

Most of the farms in this association are of the cash-grain type or general farms on which some livestock is raised. About 80 percent of the acreage is cropped to small grains, sorghum, and alfalfa. Lincoln soils are not well suited to cultivation, because they consist of stratified sand and gravel and are subject to frequent flooding. Where Lincoln and Yahola soils occur between Sand dunes, Lincoln material, much of their area is used as grassland. Good pastures of bermudagrass have been established in this association, and several areas have a dense cover of johnsongrass.

Improvements on farms within this association are few. Few bridges cross the rivers in this association, though there are good sand or gravel roads on both sides of the rivers. The river channels in this association are excellent for wildlife and recreation.

3. Kirkland-Tabler-Bethany Association

Deep, nearly level to moderately sloping soils that have a clayey subsoil

This soil association, the most extensive in the county, consists of a level to gently sloping, broad upland plain (fig. 2) that is only slightly dissected. This plain is treeless, and because of its clayey subsoil, it is commonly called hardlands. It has slopes of less than 1 percent in about 35 percent of the acreage, and it generally slopes gradually to the south. This association is well distributed throughout the central and western parts of the county. It occupies about 226,550 acres, or about 38 percent of the county.

The Kirkland soils, which make up more than 50 percent of this association, are on long, uniform, very gently undulating, convex slopes, generally below the Tabler and Bethany soils. They adjoin the Renfrow soils in the southwestern part and in the north-central part of the county along Spring Creek, where the soils are gently sloping and eroded.

The Kirkland soils have a dark grayish-brown to dark-brown, friable silt loam surface layer that is slightly acid and 8 to 14 inches thick. The subsoil of compact blocky clay absorbs water very slowly and is underlain by dark-colored heavy clay or shale.

The Tabler soils make up approximately 21 percent of this association. The larger areas of these soils are west of Blackwell in the vicinity of Nardin, west of Ponca City, northwest of Newkirk, and northeast of Braman. Tabler soils are nearly level and have a dark surface layer and a dense, claypan subsoil.

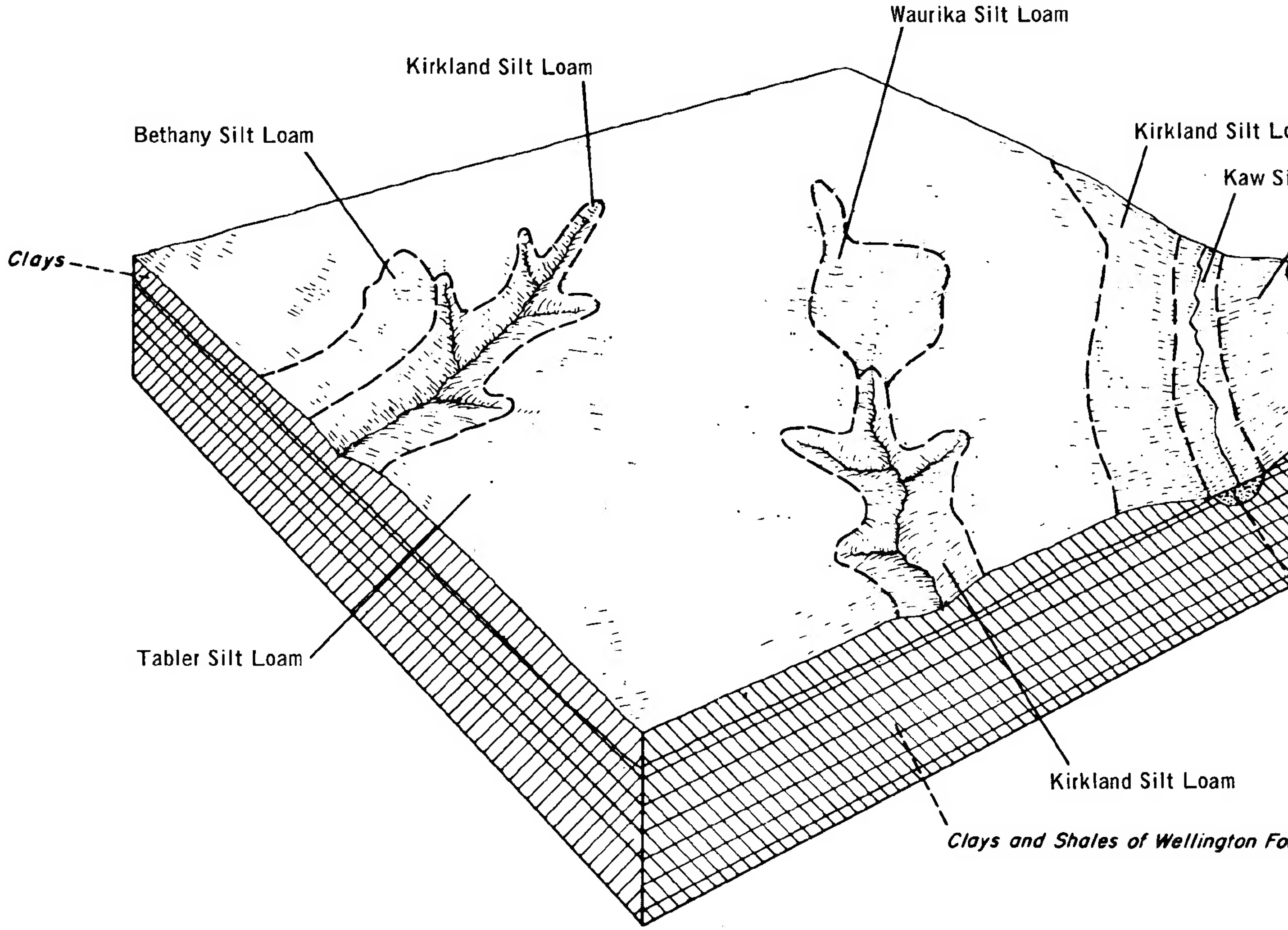

Figure 2.—**Relationship of the soils in the level to very gently sloping areas of soil association 3.**

The Bethany soils are nearly level and occur within large areas of Tabler soils, or between the Tabler soils and the more sloping Kirkland soils, which are along streams. Bethany soils make up about 10 percent of this association. In the vicinity of Newkirk, Bethany soils are surrounded by the gently sloping Kirkland soils. Bethany soils are deep and have a brown silt loam surface layer underlain by a transitional layer of clay loam about 7 inches thick. The surface layer and subsurface layer are about 16 inches thick over a brown clay subsoil. The Bethany soils are more permeable than the Kirkland or Tabler soils.

Also in this association are Norge, Vanoss, Vernon, Owens, Kaw, Waurika, and Renfrow soils. The Norge and Vanoss soils are deep and have a permeable subsoil. Vernon and Owens soils are shallow and clayey and occur in the southwestern and north-central parts of the county. The Kaw soils formed in alluvium along the upper reaches of small streams. They are deep, dark colored, permeable, and highly productive. The somewhat poorly drained, grayish Waurika soils occur in depressions within the larger areas of Tabler soils. The moderately eroded Renfrow soils are along small, V-shaped drainageways, which begin in the level to very gently sloping hardlands. In some places Renfrow soils occupy gently convex slopes below the less sloping Kirkland, Tabler, and Bethany soils. Renfrow soils are deep and brown and have a very slowly permeable subsoil.

About 80 percent of this association is cultivated. Wheat, barley, oats, and alfalfa are the main crops, and Austrian winter peas are grown as a soil-improving crop. Winter wheat, barley, and other small grains furnish considerable pasture during winter, but the pastures normally are small, overgrazed, and weedy. Farm ponds and reservoirs have been constructed in many of the natural drainageways and provide water for livestock. The chief problems of management are maintaining fertility and good tilth and controlling erosion.

4. Shellabarger-Dougherty-Eufaula Association

Deep, gently sloping or sloping, mostly loamy soils

This soil association consists of uplands that are mostly loamy and occur along the flood plains of the Arkansas River. It is in scattered areas in the eastern, southern, and western parts of the county. This association occupies 2 percent of the county, or 13,000 acres.

The Shellabarger soils occur on the uniform convex slopes and make up 60 percent of this association. These soils have a dark-colored fine sandy loam surface layer that is 10 to 18 inches thick and is underlain by a brown to reddish-brown sandy clay loam subsoil.

The Dougherty and Eufaula soils are intermingled closely and are more hummocky than the Shellabarger soils. They make up about 30 percent of the association. In most places Dougherty and Eufaula soils are closer to the river than Shellabarger soils, but they are adjacent to the Shellabarger soils in areas farther back from the river. They are the only soils in Kay County that formed under a dense cover of blackjack and post oaks. The Dougherty soils have a grayish-brown fine sandy loam surface layer 5 inches thick, a pale-brown light fine sandy loam subsurface layer 10 to 30 inches thick, and a brown to yellowish-red sandy clay loam subsoil 10 to 20 inches thick. The Eufaula soils have a grayish-brown fine sand surface layer 6 inches thick, a pale-brown fine sand subsurface layer about 20 inches thick, and underlying material of light yellowish-brown fine sand.

Also in this association are the Carwile and Pratt soils, which occur mainly in an area about 5 miles west of Tonkawa. The Carwile and Pratt soils are intermingled. They are less sloping than the Dougherty and Eufaula soils. They developed in slightly acid and medium acid, loamy to sandy, windblown deposits or old alluvium. The Carwile soils are somewhat poorly drained, and the Pratt soils are excessively drained.

Most of this association is used for small grains and sorghum, but the soils are well suited to tame pasture and truck crops. The Shellabarger are the most productive soils in this association, for the Dougherty and Eufaula soils are infertile, droughty, and subject to wind erosion. Most of the acreage of Dougherty and Eufaula soils has been cleared of trees and cultivated. The soils in this association respond favorably to good management. A cropping system is needed that protects the soils from wind erosion and maintains or improves fertility.

5. Norge-Vanoss Association

Deep, loamy, nearly level to strongly sloping soils

This soil association is made up of nearly level to gently sloping high terraces and gently sloping to sloping dissected uplands. The main areas are near Tonkawa, but the association is well distributed throughout the county, near the major streams and rivers. It makes up 77,065 acres, or about 13 percent of the county.

The Norge soils occur mainly on the gently sloping uplands within 2 miles of Chikaskia River and of local streams west of Newkirk. They make up about 60 percent of the association. They have a surface layer of brown granular loam and a subsoil of reddish-brown clay loam that absorbs water slowly but has high water-holding capacity. The Vanoss soils are on high terraces of the Arkansas River and the Salt Fork Arkansas River and make up about 33 percent of the association. They have a brown silt loam surface layer 12 to 26 inches thick and a brown silty clay loam, permeable subsoil that has high water-holding capacity. Both soils, the Norge and the Vanoss, formed in alluvial material that is as thick as 50 feet in some places, but the Norge soils are older than the Vanoss.

Also in this association are the Bethany soils and the Waurika soils. These are deep, dark-colored soils that have a clayey subsoil.

The Norge and Vanoss soils are among the most productive in the county. Almost all of the nearly level to gently sloping areas of these soils are cultivated. Wheat is the main cash crop, but all crops adapted to the area are grown.

6. Owens-Vernon Association

Shallow, sloping to steep, clayey soils underlain by redbeds

This soil association consists of gently sloping to strongly sloping soils on Permian redbeds in uplands where there are many escarpments. The main areas are near the flood plains of Bitter Creek; north of Eddy; and in the southwestern part of the county. The areas bordering Bitter Creek are mainly Owens soils, and the areas in the southwestern part of the county are mainly Vernon soils. This association occupies 12,845 acres, or about 2 percent of the county.

The Owens soils are on broken escarpments and in areas where there are outcrops of olive and gray shale. These soils have slopes of 3 to 12 percent and are dark colored, shallow, and clayey. Owens soils comprise about 36 percent of the association. They absorb water slowly, are droughty, and are highly susceptible to erosion.

The Vernon soils are gently sloping to strongly sloping and, in the steeper areas, are on a landscape similar to that of the Owens soils. Vernon soils are shallow; they formed mostly in calcareous, reddish-brown clay and shale. Like the Owens soils, Vernon soils absorb water slowly or very slowly, are droughty, and are highly susceptible to erosion. Vernon soils make up about 33 percent of the association.

Also in this association are the Summit soils and Breaks-Alluvial land complex. The Summit soils make up less than 25 percent of this association. They are deep and have a dark-colored, granular surface layer of silty clay loam to silty clay and a fine-textured subsoil. Summit soils commonly occur on gentle slopes below the more sloping Owens soils. Breaks-Alluvial land complex, which makes up less than 1 percent of this association, is in small natural drainageways that have broken side slopes.

The major soils in this association are not well suited to farming, for they are droughty and highly susceptible to erosion. Improvements on most farms are few, and the average-sized farm is less than 300 acres. More than 50 percent of the land is not suited to crops and is used as native pasture. These pastures have a low carrying capacity because they are weedy and the native grasses are short. Grazing needs to be controlled to improve the grasses and to reduce erosion.

7. Newtonia-Summit-Sogn Association

Deep and very shallow, nearly level to sloping soils underlain by limestone

This soil association, which is broken by a few steep escarpments of limestone, is on nearly level to sloping uplands in the Bluestem Hills. The larger of the two main areas is southeast of Kildare. A smaller area occupies a gently sloping divide between the Arkansas River and Little Beaver Creek. This association makes up 56,950 acres, or 9 percent of the county.

About 65 percent of the association is Newtonia soils, 15 percent is Summit, and 10 percent is Sogn. Deep Newtonia and Summit soils make up about 80 percent of this association. The Newtonia soils, which are dominant, are nearly level to sloping and lie above the moderately steep Sogn soils. Large areas of Newtonia soils occur west of the Arkansas River and extend from the Kansas State line to a point east of Ponca City. The Newtonia soils are brown and have strong granular structure.

The Summit soils are dark-colored and have a granular surface layer over a clayey subsoil that absorbs water slowly. These soils occur mainly on the broad, very gently sloping to gently sloping divide between the Arkansas River and Little Beaver Creek.

Sogn soils are closely intermingled with the deeper Summit soils in small broken or rough areas directly below limestone caps. These areas include narrow, sloping to moderately steep limestone escarpments. The Sogn soils are very shallow, dark colored, and droughty.

Also in this association are small areas of deep or moderately deep, granular Labette soils and of Breaks-Alluvial land complex. Labette soils are on strong colluvial slopes below the Sogn and Summit soils. Breaks-Alluvial land complex includes natural drainageways that drain the adjoining uplands and are used as rangeland.

Nearly all of the many farms in this association produce both cultivated crops and livestock. About 60 percent of this association is planted to small grains, mostly winter wheat, and grain sorghum, and alfalfa; the rest is in native pasture or meadow. Crop yields are favorable, but erosion is a hazard, especially in the more sloping cultivated areas. The meadows produce a large amount of high-quality hay in years of normal rainfall. All of the acreage in intermingled Sogn and Summit soils is in native pastures, and, where properly managed, produces good grazing. Water for livestock is obtained mainly from farm ponds. Sites along most drainageways are suitable for constructing additional ponds.

Roads have been built along most section lines, and nearly all county roads in this association are well graveled or well sanded.

8. Sogn-Summit-Labette Association

Very shallow and deep, rolling soils and limestone escarpments

This soil association is on very gently sloping to gently sloping tablelands that are broken by moderately steep escarpments of limestone and strong colluvial foot slopes. The largest areas occur along Little Beaver and Beaver Creeks in the eastern part of the county. The association occupies 84,110 acres, or about 14 percent of the county, and it includes grassland of the Bluestem Hills (fig. 3). It consists of about 45 percent Sogn soils, 30 percent Summit, and 10 percent Labette.

The soils in this association are very shallow and deep and are underlain by various limestone formations. In places streams have cut into the limestone to a depth of 50 to 150 feet and have formed canyons, as can be seen in the area east and northeast of Washunga. Also, the Arkansas River has carved a broad valley through this association. Small mesalike outcrops of limestone at the higher elevations are landmarks (see fig. 3). The highest elevations in the county are in this association; the range is from 1,000 feet above sea level in the southern part of the association to 1,300 feet in the northeastern part.

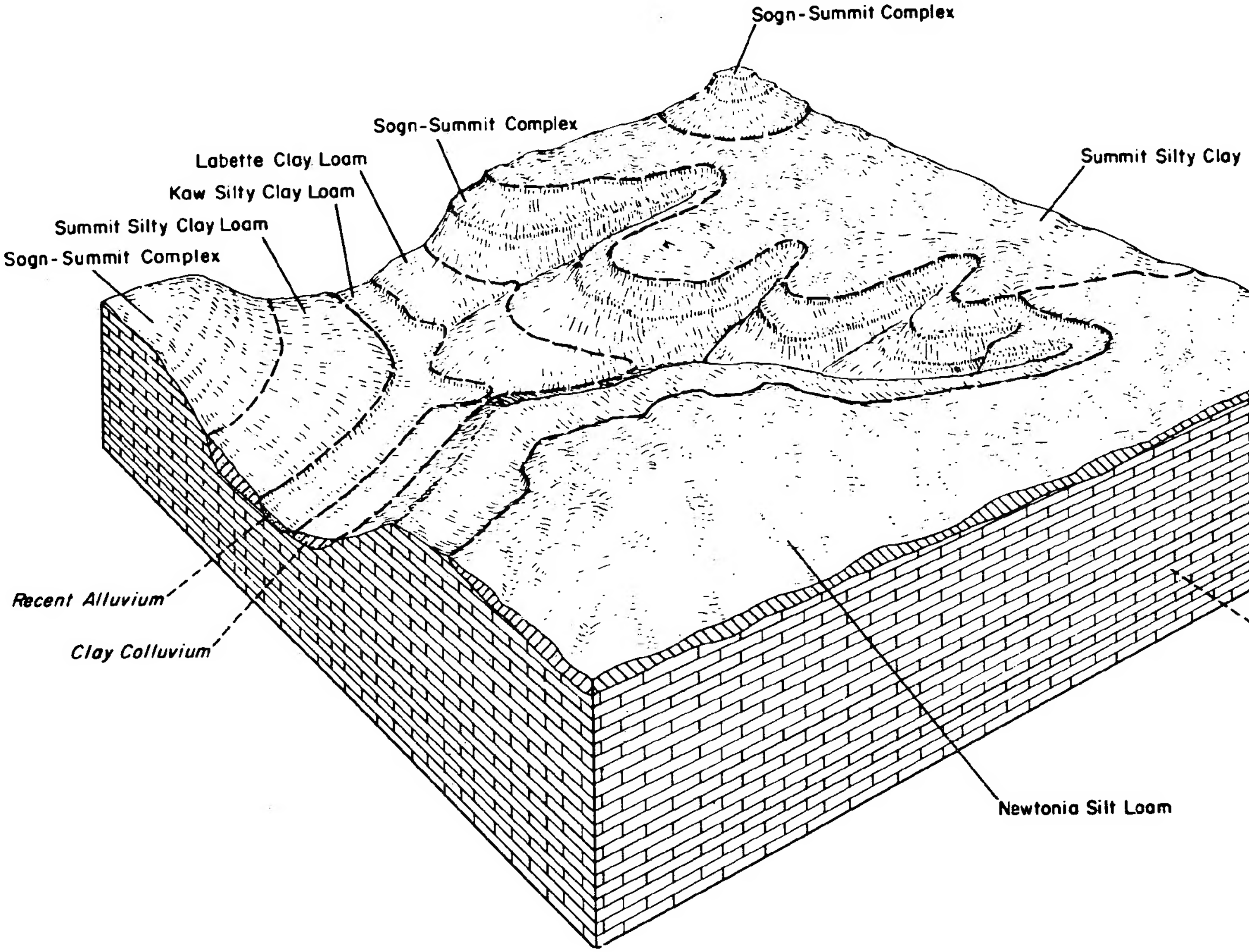

Figure 3.—Relationship of soils in the Bluestem Hills. Soil association 8.

Figure 4.—**A view of the Sogn-Summit complex in association 8. The very shallow, exposed limestone areas are Sogn soils, and the areas in native grasses are Summit soils.**

In some places the Sogn and Summit soils (fig. 4) are closely intermingled with each other and with limestone outcrops. In most areas these outcrops are escarpments, or moderately steep slope breaks, that wind around the slopes at about the same elevation. The Sogn soils are very shallow, are dark colored, and have developed in limestone and calcareous shale.

The Summit soils are deep, dark colored, and fine textured. They developed in residuum from interbedded limestone and dark-colored shale. Summit soils occupy the gentle colluvial slopes in the valleys and the very gentle slopes above the escarpments of Sogn soils. Below these escarpments on colluvial foot slopes are the Labette soils. These soils are deep and granular.

Newtonia soils are also in this association. These very gently sloping to gently sloping soils have a less clayey subsoil than have the Summit and Labette soils.

This association is mainly in large ranches. About 90 percent of the acreage is used as native grass pasture, and small grains and sorghum are grown as supplemental feed for livestock. The more shallow Sogn soils produce only a small amount of forage, but if properly managed, the deep Summit soils produce large amounts of bluestem or other grasses. A small acreage of excellent hay meadow also occurs in this association. Good management of grazing and control of erosion are needed throughout the association. Water for livestock is obtained from ponds and from local streams that are fed by springs. Sites suitable for ponds occur along many drainageways.

Roads have not been built along many of the section lines in this association, because the ranches are large and the terrain is broken. The county roads that have been built are well graveled or well sanded.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Kay County, where they are located, and how they can be used.

They went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of

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natural layers, or horizons, in a soil; it extends from the surface down into material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this soil survey efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Kaw and Kirkland, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that go with their behavior in the natural, untouched landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Kaw silt loam and Kaw silty clay loam are two soil types in the Kaw series. The difference in texture of their surface layer is apparent from their names.

Some types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. For example, Vanoss silt loam, 0 to 1 percent slopes, is one of four phases of Vanoss silt loam, a soil type that ranges from nearly level to sloping.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that greatly help in drawing boundaries accurately. The soil map in the back of this soil survey was prepared from the aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning management of farms and fields, a mapping unit is nearly equivalent to a soil type or a phase of a soil type. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil type or soil phase.

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soil in it, for example, Sogn-Summit complex, 5 to 20 percent slopes. Also, on most soil maps, areas are shown that are so rocky, so shallow, or so frequently worked by wind and water that they scarcely can be called soils. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Broken alluvial land or Oil-waste land, and are called land types rather than soils.

While a soil survey is in progress, samples of soils are taken, as needed, for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soils in other places are assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soils. Yields under defined management are estimated for all the soils.

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in a way that it is readily useful to different groups of readers, among them farmers, ranchers, managers of woodland, engineers, and homeowners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in the soil survey. On basis of the yield and practice tables and other data, the soil scientists set up trial groups, and test these by further study and by consultation with farmers, agronomists, engineers, and others. The scientists then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

Descriptions of the Soils

This section describes the soil series and the single soils, or mapping units, of Kay County. The acreage and proportionate extent of each mapping unit are given in table 1.

The procedure in this section is first to describe the soil series and then the mapping units in the series. Thus to get full information on any one mapping unit, it is necessary to read the description of that unit and also the description of the soil series to which it belongs. As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. For example, Broken alluvial land and Oil-waste land are miscellaneous land types and do not belong to a soil series; nevertheless, they, and the other land types in the county, are listed in alphabetic order along with the series.

Following the name of each mapping unit, there is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit are the capability unit, range site, and the woodland suitability group in which the mapping unit has been placed. The pages on which each capability unit, each range site, and each woodland suitability group are described can be found by referring to the "Guide to Mapping Units" at the back of this survey.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Acres	Percent	Soil	Acres	Percent
Bethany silt loam, 0 to 1 percent slopes	23, 180	3. 8	Norge loam, 3 to 5 percent slopes, eroded	8, 460	1. 4
Breaks-Alluvial land complex	11, 680	1. 9	Norge loam, 5 to 8 percent slopes	2, 455	. 4
Brewer silty clay loam	14, 780	2. 5	Norge loam, 5 to 8 percent slopes, eroded	1, 360	. 2
Broken alluvial land	7, 190	1. 2	Norge-Albion complex, 3 to 5 percent slopes	1, 115	. 2
Carr fine sandy loam	5, 610	1. 0	Oil-waste land	1, 970	. 3
Carwile-Pratt complex, undulating	2, 390	. 4	Owens clay, 3 to 12 percent slopes	4, 410	. 7
Dale clay loam	2, 960	. 5	Port silt loam	9, 510	1. 6
Dale silt loam	1, 220	. 2	Port soils, frequently flooded	2, 475	. 4
Dougherty-Eufaula complex, 0 to 3 percent slopes	870	. 1	Pratt loamy fine sand, hummocky	740	. 1
Dougherty-Eufaula complex, 3 to 8 percent slopes	3, 350	. 6	Reinach loam, 0 to 1 percent slopes	16, 830	2. 8
Eroded clayey land	1, 560	. 3	Reinach loam, 3 to 8 percent slopes	1, 530	. 3
Eroded loamy land	630	. 1	Renfrow-Kirkland silt loams, 3 to 5 percent slopes	5, 810	1. 0
Humbarger loam	2, 580	. 4	Sand dunes, Lincoln material	2, 840	. 5
Kaw silt loam	5, 570	1. 0	Shellabarger fine sandy loam, 1 to 3 percent slopes	2, 010	. 3
Kaw silty clay loam	24, 200	4. 0	Shellabarger fine sandy loam, 3 to 5 percent slopes	3, 240	. 5
Kirkland silt loam, 1 to 3 percent slopes	94, 490	15. 6	Shellabarger fine sandy loam, 5 to 8 percent slopes	610	. 1
Kirkland-Renfrow complex, 2 to 5 percent slopes, eroded	41, 655	6. 9	Sogn soils, 1 to 3 percent slopes	3, 120	. 5
Labette clay loam, 5 to 8 percent slopes	9, 730	1. 6	Sogn-Summit complex, 5 to 20 percent slopes	51, 000	8. 4
Labette-Slickspots complex, 3 to 5 percent slopes, eroded	1, 560	. 3	Summit silty clay loam, 1 to 3 percent slopes	5, 210	. 9
Lela clay	11, 360	1. 9	Summit silty clay loam, 3 to 5 percent slopes	10, 430	1. 7
Lela-Slickspots complex	2, 670	. 4	Summit silty clay, 3 to 5 percent slopes, eroded	3, 825	. 6
Lincoln soils	1, 015	. 2	Tabler silt loam, 0 to 1 percent slopes	47, 200	7. 8
Loamy broken land	1, 480	. 2	Vanoss silt loam, 0 to 1 percent slopes	9, 030	1. 5
McLain silt loam	2, 170	. 4	Vanoss silt loam, 1 to 3 percent slopes	10, 120	1. 7
McLain silty clay loam	2, 260	. 4	Vanoss silt loam, 3 to 5 percent slopes	2, 930	. 5
Miller clay	1, 930	. 3	Vanoss silt loam, 5 to 8 percent slopes	2, 600	. 4
Newtonia silt loam, 0 to 1 percent slopes	1, 430	. 2	Vernon clay loam, 3 to 5 percent slopes	2, 580	. 4
Newtonia silt loam, 1 to 3 percent slopes	18, 960	3. 1	Vernon soils, 5 to 12 percent slopes	1, 820	. 3
Newtonia silt loam, 3 to 5 percent slopes	25, 190	4. 2	Waurika silt loam	7, 000	1. 2
Newtonia clay loam, 3 to 5 percent slopes, eroded	8, 050	1. 3	Yahola fine sandy loam	6, 745	1. 1
Norge loam, 0 to 1 percent slopes	1, 950	. 3	Yahola loamy fine sand	995	. 2
Norge loam, 1 to 3 percent slopes	18, 760	3. 1	Rock quarry	460	. 1
Norge loam, 3 to 5 percent slopes	14, 130	2. 3	Rivers	7, 170	1. 2
			Total	604, 160	100. 0

Soil scientists, engineers, students, and others who want detailed descriptions of the soil series should turn to the section "How Soils Are Formed and Classified." Many terms used in the soil descriptions and other sections are defined in the Glossary and the "Soil Survey Manual" (*6*).[1]

Albion Series

The Albion series consists of deep to moderately deep, granular soils that developed in beds of unconsolidated gravelly material. These soils occur with the Norge soils in the sloping uplands on the lower part of uniform slopes that grade to adjoining bottom lands.

The Albion soils have a few quartz pebbles on the surface. The surface layer is brown sandy loam that has granular structure, is friable when moist, and is about 8 inches thick. Between depths of 8 and 13 inches is reddish-brown heavy fine sandy loam. The subsoil extends from a depth of 13 to 26 inches and consists of reddish-brown sandy clay loam that has moderate, medium, granular structure. Below 26 inches is yellowish-red coarse sand and gravel that is loose when moist or dry. The surface layer is medium acid, and the subsoil and lower horizons are medium acid to slightly acid.

[1] Italic numbers in parentheses refer to Literature Cited, p. 85.

The Albion soils have medium to rapid internal drainage. They have medium to low natural fertility and moderately low water-holding capacity. Water erosion is a serious hazard in the more sloping areas.

The main crops on these soils are small grains and grain sorghum. Yields are moderately low. Crops lack sufficient moisture for good growth in areas where the soils contain a large amount of gravel. On these soils the native vegetation consists of big bluestem, little bluestem, indiangrass, and switchgrass.

In this county the Albion soils are mapped only in a complex with Norge soils.

Bethany Series

The Bethany series consists of deep, dark, productive soils of the nearly level uplands in the central and western parts of the county. These soils are in smooth, well-drained areas, where they developed from alkaline, clayey and silty earths of the undissected old alluvial plains.

The surface layer is a dark grayish-brown to brown, granular, friable silt loam 8 to 14 inches thick. It is medium acid and slightly acid. The subsurface layer is about 6 inches thick and consists of brown, friable clay loam that absorbs water well. The subsoil is at a depth of about 16 inches and is brown, moderately compact, and clayey. This clayey material is arranged in shiny blocks (fig. 5) that have many clay films on their surface.

Figure 5.—Profile of Bethany silt loam, 0 to 1 percent slopes, showing blocky structure in the subsoil.

Below a depth of about 4 feet, the substratum is brown silty clay loam that is mottled with shades of red and gray.

The Bethany soils are well drained, have high natural fertility, and are moderately easily penetrated by roots. They absorb water in large amounts and store it for use by plants. Although water soaks slowly into the clayey subsoil, runoff is slowed by the nearly level relief.

Nearly all of the acreage of these soils is cultivated. Winter wheat is the main crop, though all crops adapted to the area are well suited. In native pasture the vegetation consists mainly of big bluestem, little bluestem, indiangrass, and switchgrass.

Bethany silt loam, 0 to 1 percent slopes (BeA).—This soil is on smooth upland divides throughout the central and western parts of the county. The soil typically has a silt loam surface layer that grades to a clayey subsoil at about 16 inches. The larger areas are in the vicinity of Newkirk. This soil occurs with the Tabler, Kirkland, and Norge soils, generally at a higher elevation than the Tabler and Kirkland soils.

This deep, well-drained soil is easy to till. It has moderate water-holding capacity, but it may be somewhat droughty during long dry periods. Because slopes are nearly level, erosion is likely only in areas adjacent to drainageways or steeper slopes.

This is one of the most productive soils in the county. Much of it is cultivated to small grains, chiefly winter wheat, but alfalfa, grain sorghum, and other crops also produce favorable yields. Favorable yields can be expected year after year if fertility, tilth, and structure are maintained. Among the practices that help to maintain tilth and the content of organic matter is growing high residue crops and legumes in the cropping system. About 7 percent of this soil is in meadow or native pasture. (Capability unit I–2; Loamy Prairie range site; woodland suitability group 2)

Breaks-Alluvial Land Complex

Breaks-Alluvial land complex (Bk) consists of land types in the prairie uplands at the bottoms and on the sides of small natural drainageways that flow into local streams. These drainageways are long. They are 100 to 300 feet wide and as much as 20 feet deep. The slopes at the bottoms of the drainageways generally do not exceed 2 to 3 percent, but the side slopes and escarpments average about 10 percent and are steep in places. The narrow bottoms are frequently flooded and contain dark-colored, loamy recent alluvium. In contrast, the side slopes, or breaks, consist of loamy and clayey materials that range from clay loam to clay. In some places the channel has cut through the alluvium and has exposed the underlying clay and shale.

Because slopes are strong, runoff is rapid, and flash floods are frequent, this mapping unit is susceptible to severe erosion and is not suitable for cultivation. Nearly all of it is used for pasture. The native vegetation consists of mixed tall and short grasses and a few scattered elm and cottonwood trees on the flooded bottom lands. The yield of forage is fair to good where this land is well managed. (Capability unit VIe–4; Breaks in the Loamy Prairie range site, and Alluvial land in the Loamy Bottom-land range site; woodland suitability group 2)

Brewer Series

The Brewer series consists of deep, dark-colored, slowly permeable soils on bottom lands, mainly along the Chikaskia River. These soils are on high benches, normally not close to the river channel. They formed in moderately fine textured, calcareous old alluvium that was laid down very slowly.

The Brewer soils have a grayish-brown silty clay loam surface layer that is about 8 inches thick and has moderate, medium, granular structure. The subsoil of dark-gray clay extends to a depth of 34 inches and has moderate, medium to coarse, blocky structure. When moist, many of the blocks in the subsoil have a dull shine on their surfaces. This shine is from clay skins that are characteristic of old soils that have clearly expressed horizons. The lower part of the subsoil is more silty

than the upper part, and its structure is less blocky and more massive as depth increases. Small, black, shotlike concretions are in this lower part of the subsoil. The substratum is at a depth of about 34 inches and consists of dark yellowish-brown heavy silty clay loam that has fine faint mottles of yellowish brown and dark grayish brown. In the slightly lower areas of these soils, the substratum is more grayish than it is in higher areas and contains more clay. The surface layer is medium acid to slightly acid, and the lower subsoil is alkaline.

Brewer soils are high in natural fertility. Although runoff and internal drainage are slow, drainage generally is adequate for excellent crop yields. These soils are deep enough to allow good storage of moisture and growth of roots. Also, the clayey subsoil holds water well and in years of normal rainfall furnishes ample moisture for crops. No injurious salts are present. In some areas, these soils are subject to floods about once in 5 to 10 years, but crops are damaged only slightly, if at all.

These soils are largely in cultivation, though tillage is moderately difficult. Yields of small grains, sorghum, and alfalfa are favorable. In native pastures the principal vegetation is tall grasses, mainly big bluestem, switchgrass, and indiangrass.

Brewer silty clay loam (0 to 1 percent slopes) (Bm).—This deep, dark-colored soil is on high benches. At about 8 inches is a very slowly permeable dark-gray clayey subsoil. Included in areas mapped as this soil are areas of Lela clay in small depressions and areas of Kaw silty clay loam near the stream channels. Together these inclusions make up less than 7 percent of the mapping unit.

This nearly level soil is well suited to crops, but it is low and concave in a few areas and, during wet years, ditching may be needed to remove excess water. Erosion is not a hazard. (Capability unit I-1; Heavy Bottomland range site; woodland suitability group 1)

Broken Alluvial Land

Broken alluvial land (Br) occurs in narrow belts along streams and consists of alluvial sediments in broken and steep areas throughout the county. The slopes range from 0 to 15 percent or more. In width the areas range from about 100 feet in the narrowest areas to as much as 500 feet where the stream meanders or where old oxbows occur. Broken alluvial land has a gradual slope downstream.

The soil materials in this mapping unit are loamy, dark colored, and noncalcareous to mildly calcareous. They are similar to the material in Yahola, Port, Kaw, and other associated soils. Fresh deposits of alluvium are added to the surface each time this land is flooded.

The native vegetation is that generally found in the county in bottom-land forest. Cottonwood, elm, some oaks, and pecan occur, and there is a mixed undergrowth of shrubs and tall grasses. This land is an excellent habitat for wildlife and is used mainly for that purpose. Where it adjoins larger areas of grass or wheat pasture, however, it is used as range. (Capability unit Vw-1; Loamy Bottom-land range site; woodland suitability group 2)

Carr Series

The Carr series consists of deep, dark-colored, loamy soils along the Arkansas River on bottom lands that are flooded at varying intervals. These soils developed in sandy to loamy, brownish, calcareous sediments that contain a large amount of weatherable minerals.

The surface layer is grayish-brown, granular fine sandy loam about 15 inches thick. The subsoil is similar to the surface layer but is weakly stratified with loamy sand to light loam. It is very friable when moist. Below a depth of 34 inches, the fine sandy loam is lighter in color, and is massive or single grained, and in places is more sandy than fine sandy loam. Stratified fine sand to light clay loam is common in this lower horizon. These soils are calcareous to noncalcareous to a depth of about 36 inches and are calcareous below that depth.

Carr soils are well drained and moderately well drained. Runoff is slow because the soils are nearly level and have moderately rapid permeability in the subsoil. If rainfall in the upper basin of the Arkansas River is intense, damaging floods may occur. These soils are porous, permeable to air and water, and moderate in natural fertility. They are slightly susceptible to wind erosion. Response to management is good.

About 80 percent of the acreage of these soils is used for small grains and sorghum. Also grown are alfalfa and bermudagrass The bermudagrass is well suited. The vegetation in native pasture consists mostly of switchgrass and bluestem grasses, but many areas are densely covered with johnsongrass.

Carr fine sandy loam (0 to 1 percent slopes) (Ca).—This soil has a deep, dark, stratified fine sandy loam profile. In places the texture of the surface layer varies from flood to flood as sandy to clayey sediments are deposited. The darker, finer textured material generally is in the slightly lower areas between slightly higher areas that are lighter colored and more sandy. Less than 5 percent of the areas mapped is Humbarger loam.

This friable soil is easy to work. Yields of crops are good, but occasionally floods may delay planting or drown crops. All crop residue should be kept in or on this soil to reduce wind erosion. This soil is suitable for irrigation, but only a few areas are irrigated. Because water is absorbed rapidly, sprinkling is the best way to irrigate. (Capability unit IIw-3; Loamy Bottom-land range site; woodland suitability group 1)

Carwile Series

The Carwile series consists of deep, nearly level to depressional, loamy soils on uplands, mostly in a small area west of Tonkawa. These soils have a mottled sandy clay loam to clay subsoil. They formed in alluvial sand and clay that have been reworked by wind and are underlain by clay and shale of Permian age.

The surface layer is dark grayish-brown, granular fine sandy loam about 7 inches thick. The subsurface layer, 4 to 14 inches thick, is dark yellowish-brown light sandy clay loam. At a depth of about 20 inches is a subsoil of very slowly permeable clay that is grayish brown mottled with dark yellowish brown. The subsoil has blocky structure or is massive. Below a depth of 28

inches is light brownish-gray, massive clay that is mottled with shades of brown and gray and contains many concretions of iron oxide. These soils are strongly acid in the surface layer, but acidity decreases as depth increases, and the subsoil is neutral. These soils are calcareous below a depth of 28 inches.

Carwile soils are somewhat poorly drained. Runoff is slow to very slow, and water commonly ponds on the surface for a few days during rainy periods. Water erosion is generally not a hazard, but wind erosion is. These soils are moderately high in plant nutrients.

Most of the acreage of Carwile soils is cultivated, generally to small grains and sorghum. Crop yields are favorable, except in the small depressions where water stands for extended periods. Native pastures are mainly in switchgrass, big bluestem, and little bluestem. In this county Carwile soils are mapped only as a complex with Pratt soils.

Carwile-Pratt complex, undulating (CuB).—This complex consists of Carwile soils and Pratt soils that occur in such an intricate pattern that it was not practical to show them separately on the soil map. Slopes mainly range from 0 to 3 percent. Carwile soils make up 35 to 70 percent of the complex, and Pratt soils make up 20 to 60 percent. The Carwile soils are level to slightly depressional and are somewhat poorly drained. The Pratt soils are very gently sloping and well drained. They are slightly higher and more sandy than the Carwile soils.

The surface layer of the Carwile soils ranges from light fine sandy loam to clay loam. The Pratt soils have a surface layer of loamy fine sand. A profile typical of the Pratt soils is described for the Pratt series.

The soils of this complex are moderately difficult to farm. The more clayey areas of Carwile soils require much more power for plowing than do areas of Pratt soils. Also, water sometimes ponds on Carwile soils and drowns crops. The Pratt soils, however, are more susceptible to erosion than the Carwile soils. Crops grown on both the Carwile and the Pratt soils respond favorably to good management, and yields vary with the level of management. (Capability unit IIw-1; Carwile soils in the Sandy Prairie range site, and Pratt soils in the Deep Sand range site; woodland suitability group 2)

Dale Series

The Dale series consists of deep, dark-colored, loamy soils on low terraces along the Arkansas River. These soils are not extensive in this county. They are young soils that formed in brownish, loamy alluvium containing a relatively large amount of plant nutrients.

The surface layer is generally dark grayish-brown clay loam that averages 17 inches in thickness but ranges from 15 to 25 inches. This layer is friable when moist and has moderate, medium or fine, granular structure. The subsoil is dark-brown clay loam that is 17 to 23 inches thick and has strong, medium, granular structure. It is friable when moist, is hard when dry, and crushes to a slightly more brownish color. The substratum, to a depth of 4 feet or more, is brown, noncalcareous material that contains less clay than the subsoil. In some places stratified clayey and sandier material occurs in the substratum. The surface layer is slightly acid, and the subsoil is slightly acid to neutral.

Dale soils are permeable and have high water-holding capacity. They are easily worked and are no more than slightly susceptible to erosion. Runoff is slow to medium. These soils are moderately rich in content of organic matter and plant nutrients. They are flooded only about once in 5 to 10 years.

Almost all of the acreage of these soils is cultivated. Favorable yields of all crops commonly grown in the county are produced. The main cash crops are wheat and alfalfa. Much of the small acreage of corn grown in this county is produced on these soils. Crops respond well to good management. In native pasture or meadow the vegetation is mainly big bluestem, little bluestem, switchgrass, indiangrass, and other tall grasses.

Dale clay loam (0 to 1 percent slopes) (Dc).—This soil has a profile similar to the one described for the series. The areas are fairly broad and uniform. Included in mapping are areas of Dale silt loam in slightly high positions and of Brewer silty clay loam in slight depressions that are less well drained. Together the included areas make up less than 8 percent of the areas mapped as Dale clay loam.

This well-drained soil has high water-holding capacity and is easy to till. It is seldom flooded, and erosion is not more than slight.

This is one of the more productive soils in the county, and almost all of it is cultivated. It is well suited to intensive cropping and commonly produces favorable yields. The main crops are small grains, alfalfa, and corn. Fertility and tilth are easily maintained if good management is practiced. Good management includes use of all crop residue, minimum and timely tillage, and use of legumes. (Capability unit I-1; Loamy Bottom-land range site; woodland suitability group 1)

Dale silt loam (0 to 1 percent slopes) (Ds).—This soil is not extensive in the county. It is within larger, slightly higher areas of Dale clay loam and is normally flooded after that soil is flooded. Included in areas mapped as this soil are small spots that have a very fine sandy loam surface layer.

Dale silt loam has a dark-gray surface layer that has medium or fine granular structure. The subsoil is very dark grayish-brown clay loam that is friable when moist and contains many worm casts. The substratum is dark yellowish-brown silt loam that is slightly more sandy as depth increases.

All of this soil is cultivated. In places wind erosion is a slight hazard, but the hazard is only seasonal and can be met by timely tillage and by using crop residue. (Capability unit I-1; Loamy Bottom-land range site; woodland suitability group 1)

Dougherty Series

In the Dougherty series are grayish-brown, moderately coarse textured soils that occur on undulating to hummocky old stream terraces along the Arkansas River. The most extensive area is east of the Arkansas River and extends as a narrow belt from Newkirk Lake to a point northwest of Washunga. These soils developed under oak and blackjack forest in deep deposits of loamy sand and light sandy loam.

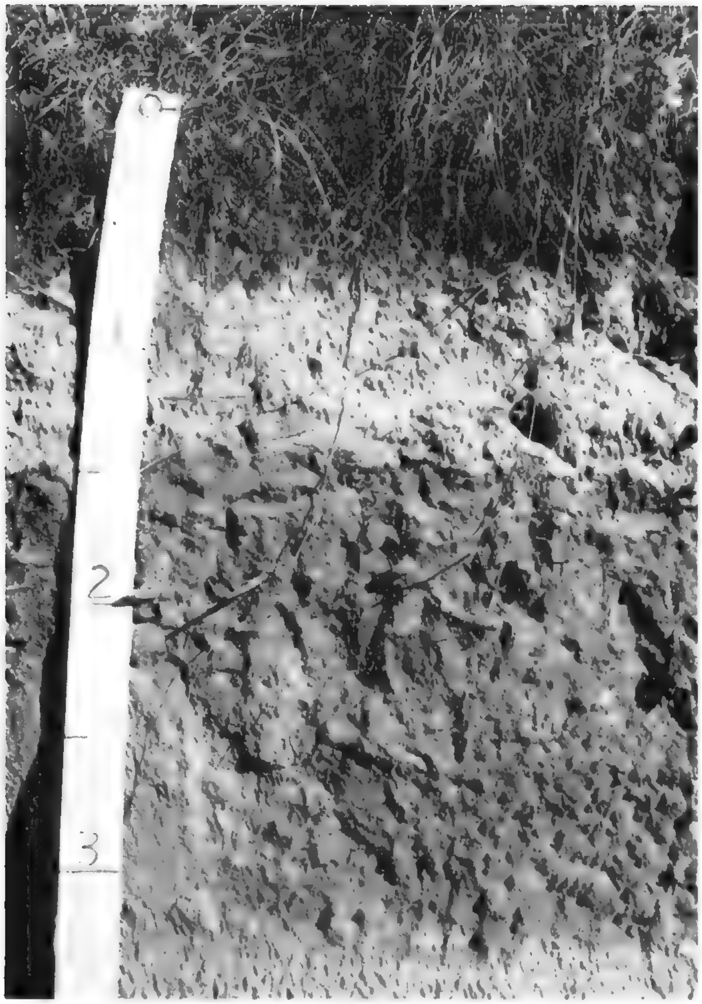

Figure 6.—**Profile of a Dougherty fine sandy loam showing the light-colored, leached horizons that are about 10 inches thick.**

The surface layer is grayish-brown fine sandy loam 5 inches thick. It has very weak, fine, granular structure and is very friable when moist. The pale-brown subsurface layer (fig. 6) of light fine sandy loam is 10 to 30 inches thick. It is massive or single grained. Below a depth of 22 inches is a subsoil of brown to yellowish-red sandy clay loam 10 to 20 inches thick. At a depth of about 32 inches is strong-brown to yellowish-red loamy fine sand that is massive or single grained, is loose when moist or dry, and is freely permeable. These soils are medium acid to slightly acid throughout the profile.

Drainage is good in these soils, runoff is rapid, and internal drainage is medium. These soils absorb water readily but hold only a moderate amount available for crops. Fertility is moderately low, partly because the light-textured subsurface layer contains only a small amount of nutrients needed by plants. In cultivated fields these soils are subject to moderate or severe wind erosion.

About 70 percent of the acreage of these soils has been cleared and is cultivated mostly to small grains. Vetch and rye are grown for temporary pasture in some areas. The permanent pastures have a cover of blackjack oak, post oak, and other scrub oaks and an understory of native grasses and legumes. In a few, small, open areas the native grasses are excellent. In this county the Dougherty soils occur only in complexes with Eufaula soils.

Dougherty-Eufaula complex, 0 to 3 percent slopes (DxB).—This mapping unit occupies undulating old stream terraces within a few miles of the Arkansas River. It consists of Dougherty and Eufaula soils that are intermingled in such an intricate pattern that it was not practical to show them separately on the soil map. It occurs with the more sloping, hummocky Dougherty-Eufaula complex and with Shellabarger fine sandy loam. The Dougherty soils make up about 55 percent of this complex, and Eufaula soils make up most of the rest. Less than 10 percent of this mapping unit consists of Shellabarger and Carwile soils.

The profiles of the Dougherty and the Eufaula soils are similar to those described for their respective series, but in some areas the surface layer is darker and thicker than normal. In a few wind-eroded spots the surface layer is thinner than normal.

Most of this complex is cultivated. Crop yields are slightly higher than those on Dougherty-Eufaula complex, 3 to 8 percent slopes. Because the Dougherty soils store more moisture, they are more productive than the Eufaula soils. The soils in this complex are suited to tame pasture and truck crops. Crops respond readily to the use of fertilizer or legumes. Areas in native pasture provide moderate amounts of grazing. (Capability unit IIIe-5; Deep Sand Savannah range site; woodland suitability group 2)

Dougherty-Eufaula complex, 3 to 8 percent slopes (DxC).—Many areas of this complex consist of low narrow ridges or dunes alternated with gently sloping valleys only a few yards wide. Other areas are on strong slopes between bottom lands of the Arkansas River and high terraces. Although the slopes are dominantly between 3 to 8 percent, they average about 5 percent and are as much as 10 percent in some places. The Dougherty soils make up about 55 percent of this complex, and Eufaula soils make up most of the rest. The Dougherty and Eufaula soils have profiles similar to the ones described for their respective series.

These soils are subject to wind erosion unless they are protected by vegetation. In some cultivated fields wind erosion has removed much of the surface layer. On some eroded knobs the sandy clay loam subsoil of the Dougherty soils is exposed.

Nearly all of the acreage of these soils was once covered with trees, but most areas have been cleared and cultivated. Small grains are the main crops. (Capability unit IVe-6; Deep Sand Savannah range site; woodland suitability group 2)

Eroded Clayey Land

Eroded clayey land (2 to 8 percent slopes) (Es) consists of eroded clayey soils that have been severely eroded by water and are no longer suitable for cultivation. It occurs within areas of Kirkland, Renfrow, and Vernon soils in the central and western parts of the county and within areas of Labette and Summit soils in the eastern part. Most areas are around the heads of natural drains where water concentrates.

Sheet and gully erosion have reached an advanced stage on this land. In many places the gullies are 2 to 5 feet deep and 10 to 15 feet wide. In some areas between the gullies, the soil is only slightly eroded and has a surface layer as much as 6 to 8 inches thick. In these gullies the surface layer is clay subsoil material or underlying material. Slickspots are numerous.

This land type makes up only a small part of the county. Most areas are idle and are sparsely covered with undesirable grasses, but many of the areas could be seeded to suitable native grasses. Even under improved management, however, a long time is required to bring this land into production. (Capability unit VIe–1; Eroded Clay range site; woodland suitability group 4)

Eroded Loamy Land

Eroded loamy land (2 to 8 percent slopes) (Et) consists of loamy uplands that are so severely eroded and gullied that they are no longer usable as cropland. Most areas have slopes greater than 5 percent. This land generally occurs around the heads of drainageways within areas of Norge and Shellabarger soils and of Dougherty-Eufaula complexes. Areas are commonly 1 to 5 acres in size, and the total acreage in the county is small.

In some places this mapping unit has lost all of its surface layer, but in other places erosion is only slight. Gullies 10 feet deep are common.

Most areas of this mapping unit are abandoned cropland that has a fair cover of native grasses between the gullies. At a great cost some of these areas could be reclaimed and used for bermudagrass pasture. (Capability unit VIe–2; Loamy Prairie range site; woodland suitability group 4)

Eufaula Series

The Eufaula series consists of deep, light-colored, loose sands that are moderately low in fertility. These soils occur near the Arkansas River on undulating to hummocky old high stream terraces. They developed under a scrub oak forest in thick beds of sandy alluvium or of wind-laid deposits.

The surface layer is grayish-brown fine sand 6 inches thick. It has weak granular structure and is loose when dry. The subsurface layer is about 20 inches thick and consists of bleached pale-brown, single-grain fine sand. This layer is very low in plant nutrients. Below a depth of 26 inches is light yellowish-brown fine sand that takes water rapidly but holds little of it available for plants. The surface layer is strongly acid, and the lower layers are medium acid.

These soils are low in fertility. Runoff is none to slight because water is absorbed rapidly. These sandy soils, however, hold only a small amount of moisture for the use of plants, and even in short dry periods they are droughty. Wind erosion is a serious hazard. In the more sloping areas adjacent to drainageways, these soils are slightly susceptible to water erosion. Gullying is slow to begin, but once it has started, there is no hard layer to resist it.

Most of the acreage of Eufaula soils is cultivated, but yields of crops are low. The main crops are small grains. Crops on these soils respond readily to the use of legumes and to additions of fertilizer. Blackjack oak, post oak, and an undergrowth of grasses and scrubs make up the vegetation in native pastures.

In this county Eufaula soils are mapped only in complexes with Dougherty soils.

Humbarger Series

The Humbarger series consists of well-drained, fertile soils along the Arkansas River on nearly level flood plains that are 10 to 20 feet above the river channel. Humbarger soils occur as long, narrow strips within areas of Carr soils near the river. They also occur in larger, more uniform areas near the adjoining uplands, away from the river. These soils developed in brown, calcareous, loamy alluvium.

The surface layer is grayish-brown loam that is about 14 inches thick and has moderate, medium, granular structure. It is very friable when moist and slightly hard when dry. This layer grades to a dark grayish-brown silt loam subsoil 10 to 30 inches thick. The subsoil is friable when moist and has weak subangular blocky structure. Below a depth of about 30 inches is brown silt loam that is weakly stratified with clay loam and fine sandy loam. Some stratification with slightly more sandy or clayey material is common in all horizons. These soils are generally calcareous throughout. In some areas, however, they are mildly alkaline but noncalcareous to a depth of about 36 inches.

These soils are easily worked and are high in natural fertility. They absorb and hold large quantities of water that can be used by plants. The water table remains below a depth of 6 feet except for short periods during and immediately after floods. Flooding can be expected at intervals of 1 to 5 years.

Most of the acreage of these soils is cultivated to small grains, alfalfa, grain sorghum, and some corn. Crop yields are generally favorable. The native vegetation consists of trees and scattered tall grasses.

Humbarger loam (0 to 1 percent slopes) (Hu).—This soil occurs on the flood plain of the Arkansas River. It has a profile similar to the one described for the series. Included in areas mapped as this soil are long, narrow, more clayey areas that are less well drained than Humbarger loam and are near the adjoining upland. Small areas of Carr fine sandy loam are also included.

Humbarger loam is well suited to all crops commonly grown in the county, but occasionally a crop is destroyed by a flood. Johnsongrass invades cultivated fields, especially those in row crops. Soil erosion is not likely, but some scouring of the surface soil can be expected when the Arkansas River overflows. Also, these floods leave fresh deposits of loamy soil material in places. (Capability unit IIw–2; Loamy Bottom-land range site; woodland suitability group 1)

Kaw Series

The Kaw series consists of nearly level, fertile, dark-colored, loamy soils on the flood plains (fig. 7) of Bitter, Duck, Bois d'Arc, and Beaver Creeks, and other local creeks. The width of the flood plains ranges from a few hundred feet at the upper reaches of the streams to a half mile at the lower reaches. These soils developed in alka-

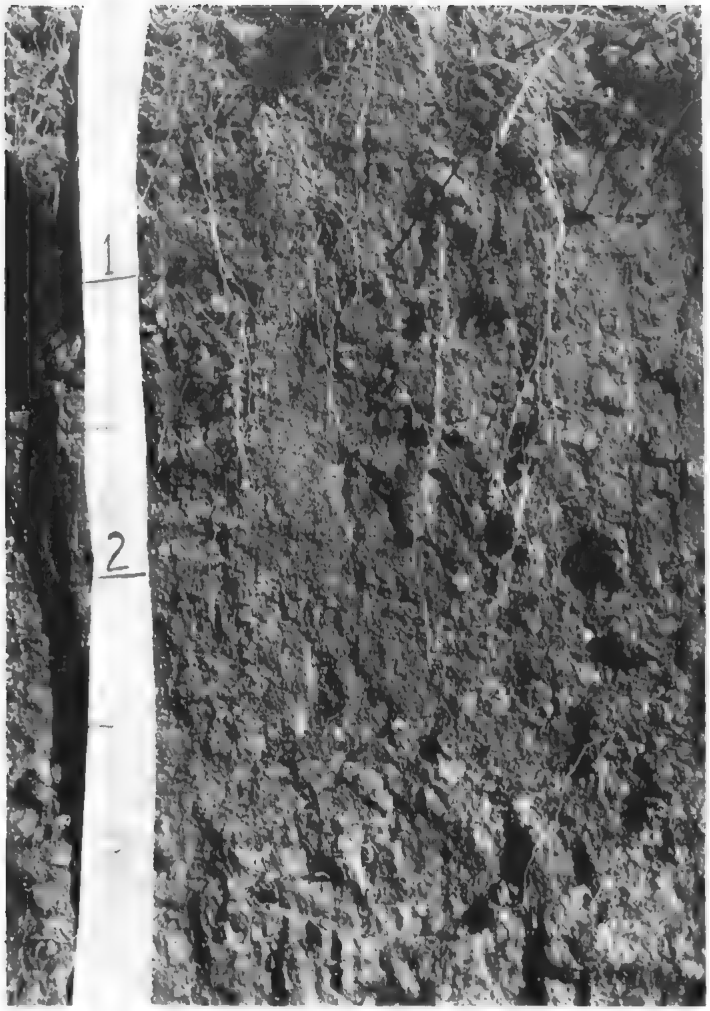

Figure 7.—**A profile of Kaw silty clay loam showing a deep, dark-colored surface layer and a moderately permeable, friable subsoil.**

line to slightly acid, silty alluvium that washed from upland areas of Tabler, Kirkland, Renfrow, Summit, and Newtonia soils.

The surface layer of Kaw soils is a very dark gray silt loam or silty clay loam about 24 inches thick. This layer is friable and has granular structure. It grades gradually to a slightly lighter colored subsoil that is weakly stratified in places, but that is otherwise much like the surface layer. Below a depth of 36 inches is brown, granular silty clay loam that is permeable to water. The surface layer is slightly acid to neutral, and the subsoil is slightly acid to mildly alkaline.

After heavy rains the Kaw soils are subject to occasional flooding, but the excess water runs off readily when the creeks return to their normal level. The soils have high water-holding capacity and are permeable to air and water.

Nearly all of the acreage of the Kaw soils is cultivated. Yields of small grains, alfalfa, and grain sorghum, the common crops, are favorable. Practices that control erosion and maintain productivity can be carried out more easily on these soils than on most of the other soils in the county. A good cover of bluestem grows in native pasture or meadow.

Kaw silt loam (0 to 1 percent slopes) (Ka).—This soil lies on level flood plains of local streams, commonly at the upper reaches where the flood plains are narrow. Included in mapping were small areas of Kaw silty clay loam.

The surface layer of Kaw silt loam is dark grayish brown about 7 to 12 inches thick. The subsoil consists of about 20 inches of silt loam and grades to the substratum of brown, friable silt loam.

This soil is generally in excellent tilth. Tilling and establishing good stands of crops are easy. The main limitation is flooding for short periods during intense rains, but normally there is only slight, if any, crop damage.

This soil is prized for farming in Kay County. All of the acreage is cultivated except the narrow bottom lands at the extreme upper reaches of the streams. Here the stream channel meanders and cuts small, irregular patches. These strips and patches are not well suited as cropland, but they provide excellent native grass or bermudagrass pasture. (Capability unit IIw–2; Loamy Bottom-land range site; woodland suitability group 1)

Kaw silty clay loam (0 to 1 percent slopes) (Kc).—This extensive soil occurs on flood plains of streams that drain into the rivers of the county. Some of the narrow, meandering streams within areas of this soil are not shown on the soil map. Included in areas mapped as this soil are small areas of Lela clay in low depressions and small areas of Kaw silt loam.

The surface layer of Kaw silty clay loam is generally very dark gray, friable, and easily worked. The subsoil is very dark grayish-brown silty clay loam.

This soil is moderately well drained, is high in natural fertility, and has high water-holding capacity. Although flooding occurs, serious damage to crops is infrequent.

Except for the narrow, irregular areas along small streams, most of this soil is cultivated. All crops adapted to the county produce favorable yields. Winter wheat and alfalfa are the main cash crops. Practices that maintain productivity and soil structure are carried out more easily on this soil than on many other soils in the county. (Capability unit IIw–2; Loamy Bottom-land range site; woodland suitability group 1)

Kirkland Series

The Kirkland series consists of deep, dark-colored soils that have a claypan subsoil. These soils are on broad, very gently sloping to gently sloping uplands in the central and western parts of the county. They developed from dark-colored clay and shale of the Wellington formation in some areas and from clayey material of the old alluvial plains in other areas.

The surface layer is dark grayish-brown to brown, fairly mellow silt loam about 10 inches thick. This layer is underlain by a dark-brown claypan subsoil (fig. 8). The claypan is uniform to a depth of 30 inches or more, except that its lower part contains less organic matter and is lighter colored. The subsoil is very firm when moist and has moderate, medium, blocky structure. The presence of clay skins is indicated by the shiny blocks of the claypan when it is moist. Below a depth of 30 to

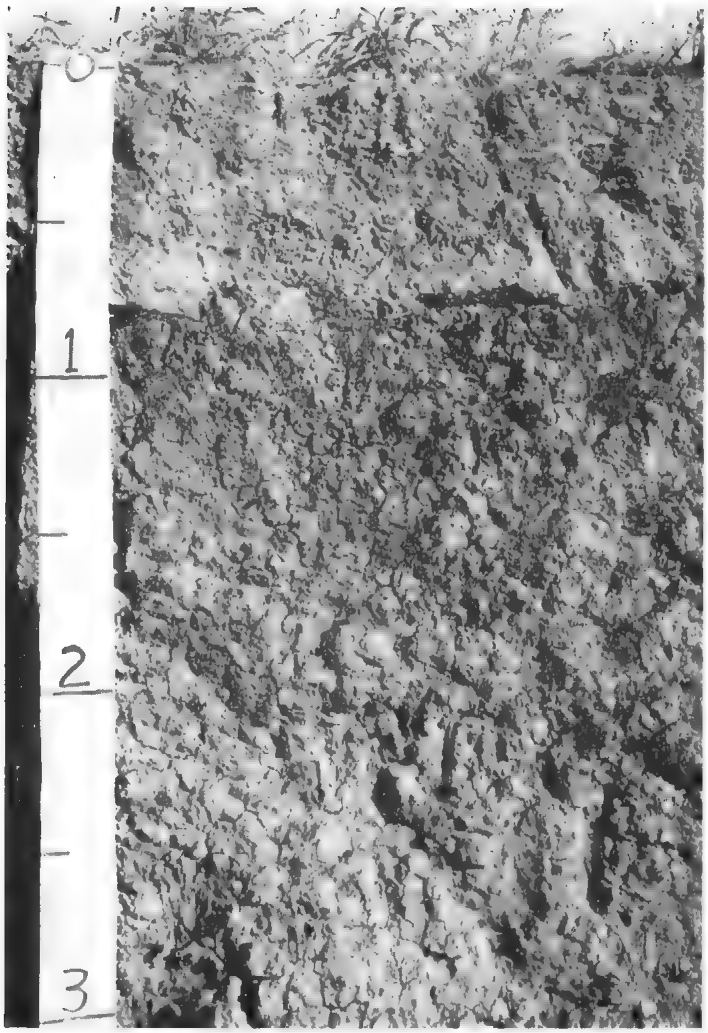

Figure 8.—**Profile of a Kirkland silt loam showing the abrupt change, at a depth of about 10 inches, from the silt loam surface layer to the clay subsoil.**

40 inches, the color grades to brown and dark reddish brown. The subsoil merges with the silty clay underlying material so gradually that it is difficult to determine the depth to which the soil developed. The surface layer and upper part of the claypan subsoil are medium acid to slightly acid, and the lower part of the claypan subsoil is neutral to alkaline. Concretions of fine lime generally occur below a depth of 30 inches.

The Kirkland soils are generally well drained, but they are excessively drained in gently sloping areas. Where tilth is good, the surface layer absorbs water readily. Rain is absorbed by the surface layer readily, but then water soaks into the claypan subsoil very slowly. During heavy storms much water runs off and washes away a large amount of surface soil. These soils have moderately high natural fertility.

Most of the acreage of these soils is cultivated. Small grains and sorghum are the main crops, and alfalfa or sweetclover is also grown. Crop yields are favorable. These soils are not well suited to summer crops, because there is generally not enough moisture in the surface layer and plants may not be able to draw enough water from the clayey subsoil. Areas in permanent pasture support a mixed growth of short and tall grasses, including buffalograss, grama, big bluestem, and little bluestem.

Kirkland silt loam, 1 to 3 percent slopes (KnB).—This soil occurs in large convex areas with Tabler and Bethany soils and other Kirkland soils. In some areas it has a thicker surface layer and a deeper profile than are typical of the Kirkland series. Included with this soil are areas of Tabler, Bethany, and Renfrow soils that together make up less than 10 percent of the area mapped.

On this soil water erosion is a serious hazard because of the slopes and the very slowly permeable, claypan subsoil. Also the surface layer tends to puddle and wash during heavy rains.

This is the major wheat-producing soil of the county. Yields of wheat are favorable. (Capability unit IIIe-1; Claypan Prairie range site; woodland suitability group 3)

Kirkland-Renfrow complex, 2 to 5 percent slopes, eroded (KrC2).—This complex occurs in the uplands on the upper parts of small eroded drainageways and on eroded, uniform, convex slopes. It is within areas of Kirkland, Tabler, Bethany, and Renfrow soils. The complex is extensive throughout the western and central parts of the county.

Kirkland soils make up from 40 to 80 percent of this complex, and Renfrow soils make up 20 to 60 percent. Slickspots are common. The percentage of Kirkland soils is greater in the central and western parts of the county where slopes are somewhat more uniform and the soils formed in darker clay and shale. The Renfrow soils make up a greater part of this complex on the small sloping knolls and in the more sloping areas in the southwestern part of the county.

In this mapping unit both the Kirkland and the Renfrow soils are more eroded and have a thinner surface layer than the soils described for their respective series. The surface layer, only 4 to 8 inches thick, ranges from silt loam in less eroded areas to clay loam in more eroded areas. Shallow rills and gullies scar the areas. In some local areas, erosion has removed all of the surface layer and has exposed the clayey subsoil. The surface layer and subsoil have been mixed by plowing in most places. In cultivated fields Renfrow soils have a more reddish surface layer than Kirkland soils.

Slickspots are generally 10 to 50 feet in diameter. Their surface layer is about 2 to 4 inches thick over compact, dark-brown clay. Crusting is severe on these slickspots.

Because the thin surface layer of these soils does not absorb much rainfall in a short period, runoff and erosion are greater than on soils that have a thicker, more permeable layer. As a result, crop yields are lower, especially during the drier seasons when moisture in deeper soils is barely adequate for plant growth.

On this complex the choice of crops is limited mainly to small grains, sorghum, and legumes. Small grains are the main crops. Yields of summer crops are low because these soils are droughty. Because of soil loss, small active gullies, and very slowly permeable subsoil, some of the fields that were cultivated have been seeded to grass. A cropping system consisting of wheat and sweetclover has proved successful for many farmers.

The sweetclover leaves a residue that makes a good mulch, and the nitrogen it supplies is beneficial to the wheat. (Capability unit IVe–2; Claypan Prairie range site; woodland suitability group 3)

Labette Series

In the Labette series are deep to moderately deep, granular, dark-colored soils that occur in the eastern part of the county. These soils developed in residuum from interbedded calcareous clay, shale, and limestone.

The Labette soils have a dark-brown clay loam surface layer that has a strong, coarse, granular structure. The subsurface layer, between depths of 9 and 18 inches, is brown clay loam that is slightly heavier than the surface layer. Roots are abundant in this layer, and a few stains of organic matter are on the surface of the peds. The subsoil is reddish-brown, blocky clay that, in the upper part, contains a few, black, shotlike concretions. Below a depth of 26 inches, the subsoil is slightly more clayey than it is above, and it contains many concretions of calcium carbonate.

The Labette soils are excessively drained. They are moderately slowly permeable and high in natural fertility. These soils are moderately difficult to till.

Labette soils are used primarily for native grass pasture consisting mainly of big bluestem and little bluestem. This native vegetation has a high carrying capacity, and yields of hay are good. Most cultivated areas are in small grains. If these soils are tilled, water erosion is likely.

Labette clay loam, 5 to 8 percent slopes (LaD).—This soil is mostly in the eastern part of the county, where it occupies sloping, colluvial foot slopes below the prominent limestone escarpments that are in the Sogn-Summit complex, 5 to 20 percent slopes. Directly below these escarpments in the more sloping parts, this Labette clay loam contains a few outcrops of limestone and seepy wet spots. Included in areas mapped as this soil are a few, narrow, uncrossable gullies. In the southeastern corner of the county, the surface layer of this soil is browner and thinner than normal and is underlain by redder clay. In a small area north of Beaver Creek, some chert fragments are in the profile.

About nine-tenths of this soil is native grassland on which good range management is needed to reduce erosion and to keep the desirable grasses vigorous and productive. The rest is cropland and is mostly west of the Arkansas River. Small grains are the most important crop.

This soil is moderately difficult to till. Cultivated areas are susceptible to severe water erosion. Suitable practices for conserving soil and moisture are terracing, tilling on the contour, and growing of legumes. In areas below the Sogn-Summit complex, diversion terraces are needed to carry excess water safely away from the cultivated fields. Crops grown on this Labette soil respond well to additions of fertilizer. (Capability unit IVe–3; Loamy Prairie range site; woodland suitability group 3)

Labette-Slickspots complex, 3 to 5 percent slopes, eroded (LbC2).—This mapping unit occupies gently sloping areas around the heads of intermittent drainageways and in other places where water concentrates. It occurs with Newtonia soils, mostly Newtonia clay loam, 3 to 5 percent slopes, eroded. About 40 to 60 percent of this complex is eroded Labette clay loam. Slickspots make up 10 to 35 percent, but generally they average about 20 percent. Between the irregular patterns of Labette soil and slickspots is an intermediate soil comprising 5 to 15 percent of the area.

The surface layer of the Labette soils is 3 to 7 inches thick and is thinner than the surface layer in the profile described for the Labette series. The surface layer in the area of slickspots is about 2 to 4 inches over compact, dark-brown clay. In cultivated fields slickspots occur as thin, white, crusted spots.

The soils of this complex contain a small amount of organic matter and have low water-holding capacity. They are subject to moderate or severe water erosion. In about 60 to 80 percent of the acreage, the plow layer is a mixture of the surface layer and the subsoil.

About three-fourths of the acreage is cultivated, but productivity is low. The rest of the acreage is abandoned or idle cropland that is used for pasture. (Capability unit IVs–2; Labette soils in the Loamy Prairie range site, and Slickspots in the Slickspot range site; woodland suitability group 4)

Lela Series

The Lela series consists of very dark, somewhat poorly drained, level to slightly depressional, clayey soils on bottom lands. These soils occur in large fairly uniform areas, mainly along Birds Nest Creek, in an area south of Tonkawa, and on the second bottoms of the Chikaskia River. Lela soils formed in clayey sediments that were deposited where floodwaters move slowly or are intermittently ponded.

These soils have a surface layer of dark-gray light clay 4 to 8 inches thick. When this layer is dry, it has a gray crust about one-fourth of an inch thick that is cracked into irregularly shaped patches 2 to 4 inches across. The surface layer is black when moist. It generally has weak granular structure but is massive in places. The surface layer is very sticky when moist and very hard and cloddy when dry. It is underlain by very dark gray, dense clay that has weak blocky structure or is massive. This material is very slowly permeable and very plastic when moist. At a depth of about 44 inches, the soil material is dark-brown, massive clay. This material contains a few scattered concretions of calcium carbonate. The surface layer is slightly acid or medium acid to a depth of about 6 inches. Below 6 inches the soil material is slightly acid or neutral, and below 44 inches it contains free lime.

Most areas of Lela soils are occasionally flooded by the adjoining streams. Runoff is slow or very slow. After heavy rains, water often stands on the surface for several days. Because the subsoil is clayey, internal drainage is very slow. Natural fertility is high.

Most of the acreage of the Lela soils is cultivated, commonly to wheat, barley, and sorghum. Alfalfa is grown in areas where drainage systems have been installed. Crop yields vary considerably from year to year, but they are generally moderately low. These soils are droughty in dry years and often are excessively wet in years of average rainfall. Occasionally, when moisture is favorable throughout the growing season, crop yields are favorable. The principal grasses in native

pasture are big bluestem, switchgrass, and indiangrass. Some sloughgrass grows in the depressions.

Lela clay (0 to 1 percent slopes) (Lc).—This dark, somewhat poorly drained soil occurs chiefly in large areas on level to slightly depressional flood plains. A few areas adjacent to uplands are covered with a few inches of recent overwash and have a surface layer that varies in color and texture. Included in the areas mapped as this soil are slickspots that are less than one-fourth acre in size and are too small to delineate on the soil map. They are shown on the map by symbols.

This soil is difficult to till, and farmers sometimes have trouble establishing a good stand of crops. Also, harvesting is often delayed because the soil is wet.

Drainage limits the use of this soil for farming. In most years surface ditches are needed to remove excess water. If this soil is not drained, the response to other management is poor. Grain sorghum consistently produces higher yields than other crops because it is grown during the summer when rainfall is low and evaporation is high. (Capability unit IIIw-1; Heavy Bottom-land range site; woodland suitability group 4)

Lela-Slickspots complex (0 to 1 percent slopes) (Le).—This mapping unit consists of dark-colored, somewhat poorly drained, clayey soils on nearly level to slightly depressional bottom lands where many slickspots are scattered. Lela clay makes up about 70 to 90 percent of this complex, and the slickspots make up from 10 to 30 percent but generally average 20 percent. About 5 to 10 percent of the complex is a transitional zone between the Lela soil and the slickspots.

The Lela soil has a profile like the one described for the series, but in some places salts occur below a depth of 40 inches. In many places the slickspots are crusted with light brownish-gray, massive silt loam to clay about one-half inch thick. The surface layer ranges from 3 to 10 inches in thickness and is underlain by dark-colored, massive clay that has an accumulation of salts and absorbs water very slowly. Internal drainage is very slow. In about 35 acres in the southwestern part of the county, the soils of the complex are less clayey than those described.

About 50 percent of this complex is in small grains and sorghum, but yields are low. The rest is grassland. The chief grasses in native pasture are switchgrass, alkali sacaton, and saltgrass. (Capability unit IVs-1; Lela soil in the Heavy Bottom-land range site, and Slickspots in the Alkali Bottom-land range site; woodland suitability group 4)

Lincoln Series

The Lincoln series consists of sandy, calcareous soils that formed in recent mixed alluvium on low bottom lands of the Arkansas River. These soils are unstable because new sandy and clayey material is deposited during each flood.

These soils vary in texture, color, and depth, but in most places the surface layer is grayish-brown, calcareous loamy sand about 15 inches thick. This layer is underlain by pale-brown, stratified, calcareous sand, loamy sand, and gravel that extend to a depth of 60 inches or more.

Lincoln soils have slow runoff but very rapid internal drainage. The water table commonly is at a depth ranging from 4 to 15 feet. These soils are frequently flooded, are low in fertility, and are somewhat droughty.

These soils are poorly suited to cultivation because damaging floods are frequent and their texture is extremely sandy. Most areas are in native pasture, and many have a cover of johnsongrass. Vegetation has little time to get a foothold because fresh material is deposited during the recurring floods.

Lincoln soils (0 to 2 percent slopes) (Lm).—These inextensive soils are on sandy flood plains of the Arkansas River. Typically they have a grayish-brown loamy sand surface layer underlain by calcareous sand at 15 inches. Included in the areas mapped as these soils are soils in old meandering river channels that have been filled with silt. Also included are small areas of Carr soils and Sand dunes, Lincoln material.

Because Lincoln soils are frequently flooded, they are unstable and they vary in texture. Large floods leave deep deposits in some areas and dig potholes in others. In dry periods these soils are droughty and are susceptible to blowing. The vegetation is scattered and consists of woody shrubs, annuals, sand sagebrush, switchgrass, saltgrass, johnsongrass, cottonwood trees, and willows. Some areas could be seeded to bermudagrass. (Capability unit Vw-2; Sandy Bottom-land range site; woodland suitability group 2)

Loamy Broken Land

Loamy broken land (Lo) consists of narrow bands of sloping to steep broken slopes that separate bottom lands from the adjoining uplands. The slopes range from 5 to as much as 50 percent, but they average about 12 percent. Most areas are along the Arkansas River.

The surface layer of this land ranges from loam to silt loam in texture and from brown to dark brown in color. Although the soil material is generally thick, the underlying limestone is close to the surface in some places. Limestone crops out in about 2 to 5 percent of the area on the steeper, more broken slopes

This land is not suitable for cultivation. The native vegetation is principally trees and brush, and there are scattered tall grasses and native legumes. (Capability unit VIe-3; Loamy Prairie range site; woodland suitability group 2)

McLain Series

The McLain series consists of deep, brown to dark-brown, productive soils on low alluvial terraces along the Salt Fork Arkansas River, but above the level of normal flooding. These nearly level soils developed in reddish, calcareous alluvium that originated mainly from prairies underlain by redbeds.

These soils generally have a surface layer of dark-brown to brown, granular, friable silty clay loam 6 to 10 inches thick. The subsoil, to a depth of about 21 inches, is dark reddish-brown to reddish-brown clay that has moderate, medium, blocky structure. Below 21 inches is reddish-brown silty clay loam. This layer grades to yellowish-red silty clay loam that has weak, medium, granular structure. The surface layer is medium acid,

the subsoil is slightly acid to mildly calcareous, and the lower substratum is commonly calcareous.

Runoff is slow on these nearly level soils. Natural fertility and water-holding capacity are high. Some areas south of Tonkawa are occasionally flooded by Birds Nest Creek.

Almost all of the acreage of McLain soils is cultivated. Small grains and alfalfa are important crops and have favorable yields. The main grasses in the native pasture are switchgrass, big bluestem, and little bluestem.

McLain silt loam (0 to 1 percent slopes) (MaA).—This is one of the better soils for farming in the county. It occurs with Reinach loam, 0 to 1 percent slopes, and McLain silty clay loam.

McLain silt loam has a silt loam and heavy silt loam surface layer about 17 inches thick. The subsoil is reddish-brown clay loam that grades to yellowish-red silt loam at a depth of about 2 feet. This yellowish-red silt loam is more sandy and calcareous as depth increases.

This well-drained soil has greater water-holding capacity and is slightly more productive than McLain silty clay loam. Also, McLain silt loam is easier to farm because it is seldom, if ever, flooded. It is suited to many kinds of crops, and almost all of it is cultivated. (Capability unit I-1; Loamy Bottom-land range site; woodland suitability group 1)

McLain silty clay loam (0 to 1 percent slopes) (Mb).—This nearly level to slightly depressional soil has a heavy clay loam subsoil in some areas. Included in mapping were small areas of Lela clay and McLain silt loam. McLain silty clay loam is moderately difficult to till. Because runoff is slow and permeability is very slow, water stands on the surface for short periods after heavy rains. Drainage to remove excess surface water is needed if plant growth is to be optimum in years of above average rainfall. Erosion is not a hazard on this soil. (Capability unit I-1; Loamy Bottom-land range site; woodland suitability group 1)

Miller Series

The Miller series consists of deep, reddish, calcareous clay soils on bottom lands along the Salt Fork Arkansas River. These soils normally occupy long, narrow, slightly depressional areas surrounded by Yahola soils on first bottoms. The Miller soils formed in clayey material that was deposited by slow-moving floodwaters.

The surface layer is reddish-brown, calcareous clay about 10 inches thick. This layer ranges from weak, medium, granular structure to massive. The surface layer is very slowly permeable to water. It is directly underlain by reddish-brown, calcareous clay 8 to 20 inches thick. This layer ranges from weak, fine, blocky structure to massive. It is very sticky and plastic when wet and extremely hard when dry. It contains a few, small, scattered concretions of calcium carbonate. Between depths of about 19 and 29 inches, the soil material is yellowish-red clay loam that has weak, medium, granular structure, is friable when moist, and contains thin bands or pockets of finer textured material from the horizon above. Below a depth of 29 inches is yellowish-red to reddish-yellow, calcareous very fine sandy loam that ranges from weak granular structure to single grain or massive. Thin strata of reddish-brown clay similar to the clay in the surface layer commonly occur throughout this lower part of the profile.

Miller soils are somewhat poorly drained and are hard to farm. During wet periods crops are damaged by excessive water, and in dry periods yields are low because water-holding capacity is low. Surface crusting is common, but natural fertility is high.

On these soils the choice of crops is limited. Small grains and sorghum are the main crops, but alfalfa is grown in small areas within larger areas of Yahola soils. Alfalfa can be established without applications of lime because these soils are calcareous. Crop yields are moderate to low. Areas of these soils close to the Salt Fork Arkansas River are in native grass or improved pasture. The main grasses are switchgrass, prairie cordgrass, and big bluestem.

Miller clay (0 to 1 percent slopes) (Mc).—This soil is of limited extent in this county. It is in concave or slough-like areas of the occasionally flooded bottom lands along the Salt Fork Arkansas River. Most areas are less than 40 acres in size. The clayey subsoil of this soil is very slowly permeable, and surface water is commonly ponded after flooding or heavy rains.

Tillage is difficult on this soil, and drainage is required if yields are to be favorable. Erosion is none to slight. Most areas receive from 1 to 3 inches of fine sediments during each flood. (Capability unit IIIw-1; Heavy Bottom-land range site; woodland suitability group 4)

Newtonia Series

The Newtonia series consists of deep, brown, granular soils on uplands. These soils occur in the eastern part of the county between U.S. Highway No. 77 and the Osage County line. They formed in material weathered from limestone or from limestone interbedded with calcareous shale and clay.

The Newtonia soils generally have a brown silt loam surface layer about 9 inches thick. This layer has strong, medium, granular structure in areas in native vegetation, but it has moderate, medium, granular structure in cultivated fields. Between depths of 9 and 16 inches is a subsurface layer of reddish-brown silty clay loam that is friable when moist and has strong, medium and coarse, granular structure. Roots and worm casts are abundant in this layer. The subsoil is reddish-brown heavy silty clay loam that extends from a depth of 16 to 44 inches. Structure is strong and granular in the upper 13 inches of the subsoil and is weak, medium, subangular blocky in the lower part. Below a depth of 44 inches is yellowish-red silty clay that contains a few faint mottles of grayish brown and a few, fine, black films and concretions of manganese and iron oxides. The surface layer is slightly acid, and the layers below it are slightly acid to mildly alkaline. Depth to limestone is generally more than 4 feet.

Newtonia soils are generally well drained, but they are excessively drained in sloping areas. Their subsoil has good water-holding capacity and is moderately permeable to roots, air, and water. Natural fertility is moderately high. Water erosion is a hazard in the sloping areas.

Most of the acreage of these soils is cultivated. All crops suited to the area are grown, and small grains, alfalfa, and sorghum are the main crops. East of the Arkansas River are large areas of native pasture that produce forage of high quality. The grasses are mainly big bluestem and little bluestem.

Newtonia silt loam, 0 to 1 percent slopes (NeA).—This nearly level soil is mainly southeast of Kildare. It occupies smooth divides and occurs with the more sloping Newtonia soils. It is in fairly large areas, but its total acreage in the county is small.

The surface layer is slightly thicker than the one described for the series. The subsoil is slightly darker than the one described for the series. Because this soil is more nearly level than the other Newtonia soils in the county, it has slower runoff and is less likely to erode. Drainage is good.

This soil is desirable for farming. It can be worked easily, and crops respond well to management. Small grains, mostly wheat, grain sorghum, and alfalfa are the main crops. Almost all of this soil is cultivated. (Capability unit I–2; Loamy Prairie range site; woodland suitability group 2)

Newtonia silt loam, 1 to 3 percent slopes (NeB).—This soil is on very gentle convex slopes above limestone escarpments. It is commonly adjacent to other Newtonia soils. In some places it borders Summit soils or Sogn-Summit complex, 5 to 20 percent slopes. Included in the areas mapped as this soil are small, darker or more clayey areas of Summit or Labette soils that make up less than 6 percent of any mapped area. In about 30 to 50 percent of the area mapped, limestone is at a depth of 20 to 50 inches.

This soil has a profile similar to the one described for the series. On narrow divides directly above the sharp breaks occupied by Sogn-Summit complex, 5 to 20 percent slopes, it is less deep than typical. In some small areas near drainageways, the surface layer has been thinned by erosion.

About 70 percent of this soil is cultivated, and the rest is in native pasture. Unless management is good, erosion is likely in cultivated areas. A large part of the acreage in pasture is in small, inaccessible areas east of the Arkansas River that are surrounded by stony, very shallow soils. If the supply of organic matter and plant nutrients is kept at a high level, this soil produces favorable yields of all crops grown in the county. (Capability unit IIe–1; Loamy Prairie range site; woodland suitability group 2)

Newtonia silt loam, 3 to 5 percent slopes (NeC).—This soil occupies broad gently sloping uplands above limestone escarpments of Sogn-Summit complex, 5 to 20 percent slopes, and gentle uniform slopes below these escarpments. Included in the areas mapped as this soil are slickspots that are too small to be delineated on the maps. Slickspots are easily recognized in rangeland by their vegetation of dominantly short grasses. Also included, and making up as much as 5 percent of each mapped area, are small areas of Newtonia silt loam, 3 to 5 percent slopes, eroded. In about 40 to 50 percent of the area mapped, limestone is at a depth of 20 to 50 inches.

In most places the surface layer of Newtonia silt loam, 3 to 5 percent slopes, has been thinned slightly by erosion, or it was never so thick as the surface layer in the typical profile. Where this soil lies below escarpments of the Sogn-Summit complex, the surface layer is commonly darker than the surface layer of the less sloping Newtonia soils. Also, the subsoil is generally more clayey. In some small areas north of Beaver Creek, the lower layers contain chert fragments.

This soil is friable, moderately easy to work, and moderately productive. It is used for the same kinds of crops as the less sloping Newtonia soils, but yields are slightly lower, especially in dry years. Erosion is likely in cultivated fields. Many areas, most of them east of the Arkansas River, are in native pastures consisting of bluestem. (Capability unit IIIe–2; Loamy Prairie range site; woodland suitability group 2)

Newtonia clay loam, 3 to 5 percent slopes, eroded (NnC2).—This soil occurs mainly on side slopes along small drainageways and on uniform, moderately eroded slopes below the limestone escarpments in the Sogn-Summit complex, 5 to 20 percent slopes.

This soil has a thinner surface layer than Newtonia silt loam, 3 to 5 percent slopes, because about 30 to 60 percent of the original surface soil has been removed by sheet and gully erosion. In cultivated areas about 40 percent of the plow layer consists of material from the subsoil. In many places the subsoil is more clayey and less granular than that of the other Newtonia soils. A few slickspots commonly occur in areas of this soil. In about 40 to 60 percent of the area mapped, limestone is at a depth of 20 to 50 inches.

About 90 percent of this soil is used for small grains and sorghum, but the rest has been returned to native grass or is idle. Under good management, which includes protecting the soil from erosion, this soil can be used for cultivated crops. Almost all of the rills and gullies are so small that they do not prevent tillage. (Capability unit IIIe–3; Loamy Prairie range site; woodland suitability group 3)

Norge Series

The Norge series consists of deep, brown, friable, loamy soils that are level to strongly sloping. The main areas are west of Newkirk within a few miles of streams or rivers. These soils developed from a clayey and loamy substratum several feet thick.

The surface layer is brown loam (fig. 9) that has granular structure. The subsurface layer is brown, friable clay loam about 8 inches thick. At a depth of 16 inches is a reddish-brown heavy clay loam subsoil that has subangular blocky structure and absorbs water readily. The lower part of the subsoil is yellowish-red, slightly heavier clay loam that contains numerous particles of sand. The substratum is blocky clay loam to clay that is slightly mottled in many places. A few round pebbles of quartz commonly occur throughout the profile. The surface layer is medium acid and slightly acid, and the layers below are slightly acid and neutral.

The Norge soils are generally well drained, but they are excessively drained in the more sloping eroded areas. In the sloping areas accelerated water erosion is likely. Norge soils are high in natural fertility. They are friable and easy to till, and crops on them respond to good management.

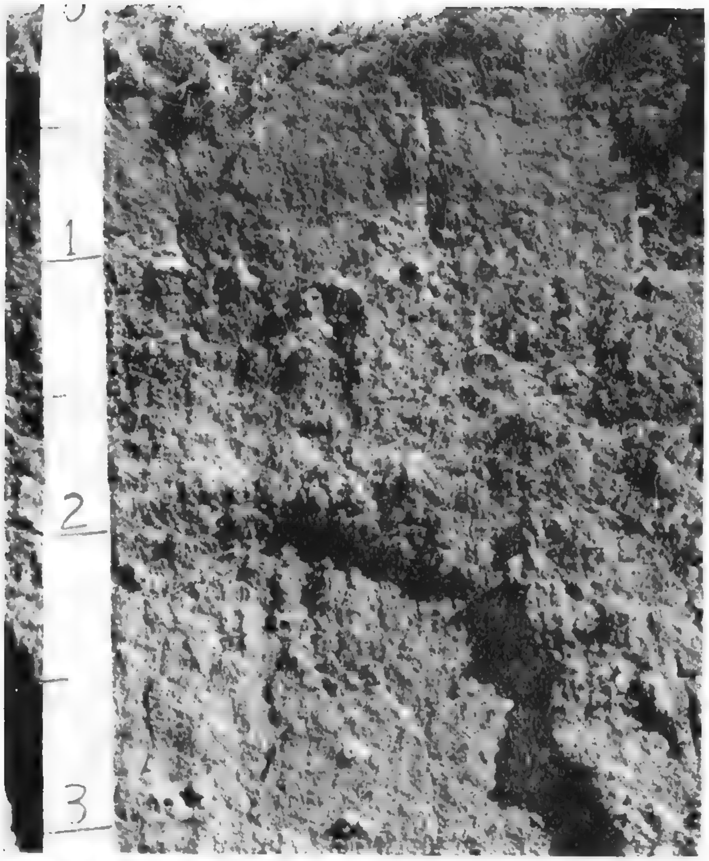

Figure 9.—**Profile of a Norge loam showing small quartz pebbles at a depth of 3 feet.**

These soils are among the most productive soils of the uplands in this county. Most of the acreage is cultivated, mainly to small grains, alfalfa, and sorghum. Because these soils hold a good supply of moisture that plants can use, they are suitable for summer crops if rainfall is average. Some areas are used as meadow. Areas of native pasture that are not overgrazed support a good cover of bluestem.

Norge loam, 0 to 1 percent slopes (NoA).—The largest areas of this soil are southwest of Ponca City, and smaller areas are well distributed throughout the central and western parts of the county. In places where the old alluvium is thickest, this soil is close to Vanoss, Bethany, and other Norge soils. Small areas of Bethany and Vanoss soils are included in areas mapped as this soil.

The surface layer of this soil is darker and slightly thicker than that of the other Norge soils. Runoff is slow because the soil is nearly level and absorbs water readily.

This is one of the best soils for farming in the county, and, except for a few pastures, all of it is cultivated. Many kinds of crops are suitable, and small grains, alfalfa, and wheat are the main crops. Yields are favorable. (Capability unit I–2; Loamy Prairie range site; woodland suitability group 2)

Norge loam, 1 to 3 percent slopes (NoB).—This extensive soil, which occurs with other Norge soils, is on very gentle convex slopes. The main areas are on broad divides in the valley of the Chikaskia River. Smaller areas are on small ridges within the areas of Kirkland soils.

This soil has a profile similar to the one described for the Norge series, except that the subsoil is more clayey in a few small areas.

This soil is easy to farm, and about nine-tenths of it is cultivated. Water erosion is not likely in the nearly level areas, but it is a hazard in the more sloping areas. Terraces and contour tillage can be used to reduce loss of soil in the more sloping areas. (Capability unit IIe–1; Loamy Prairie range site; woodland suitability group 2)

Norge loam, 3 to 5 percent slopes (NoC).—This soil occupies gentle slopes that commonly border the Chikaskia River and other streams west of Newkirk. It generally is adjacent to Norge loam, 1 to 3 percent slopes, on higher, smooth divides. Included in the areas mapped as this soil are small areas of Norge loam, 3 to 5 percent slopes, eroded, that amount to 5 to 10 percent of some cultivated fields.

In some areas the surface layer has been thinned by erosion, or it was never so thick as the surface layer in the profile described for the Norge series. In many places close to streams, the substratum contains narrow bands or pockets of sandier material. Erosion is more likely on this soil than on the less sloping Norge soils because slopes are stronger and runoff is moderate to rapid.

Most of the acreage of this soil is cultivated. Crop yields are favorable, but they are slightly lower than those on the less sloping Norge soils because the surface layer is thinner and the intake of water is less. (Capability unit IIIe–2; Loamy Prairie range site; woodland suitability group 2)

Norge loam, 3 to 5 percent slopes, eroded (NoC2).—This soil is on side slopes along intermittent drainageways and on the crests and the side slopes of gently rolling divides. It is commonly next to Norge loam, 3 to 5 percent slopes.

The surface layer of this soil, 4 to 8 inches thick, is generally slightly more reddish than the surface layer in the profile described for the Norge series. In the more eroded areas, the surface layer is less loamy and more clayey than typical. Some light-colored slickspots occur in the more eroded areas. Rills are evident around the heads of drainageways, and sheet erosion is common on the more uniform slopes.

Most of this soil is cultivated, but a few areas have been returned to native grasses. Practices are needed that slow or divert runoff and control water erosion. (Capability unit IIIe–3; Loamy Prairie range site; woodland suitability group 3)

Norge loam, 5 to 8 percent slopes (NoD).—This soil is on strong uniform slopes close to streams and intermittent drainageways.

The surface layer and subsoil are slightly thinner than those in uneroded, less sloping Norge soils. In some places the substratum is more sandy than typical, and in local spots the underlying clay and shale are closer to the surface.

Runoff ranges from moderate to rapid, depending on the amount and intensity of rainfall. Cultivated areas are subject to moderate water erosion.

About half of this soil is cultivated, mainly to small grains. (Capability unit IVe–3; Loamy Prairie range site; woodland suitability group 3)

Norge loam, 5 to 8 percent slopes, eroded (NoD2).—This soil is on short slopes along intermittent drainageways. In many areas it adjoins bottom lands of the Chikaskia River.

This soil is more sloping than the surrounding Norge soils and has a thinner surface layer. In places the subsoil is more clayey and less permeable than that in the profile described for the Norge series. In a few small areas clay and shale are at a depth of about 36 inches. Slickspots less than one-fourth of an acre in size occur in the more eroded areas.

Accelerated erosion is the main hazard in cultivated areas. In many places tillage has mixed material from the subsoil into the original surface layer. In many of the small rills, which are about 50 to 75 feet apart, the subsoil is exposed. Natural fertility and the content of organic matter are moderately low.

All of this soil has been cultivated, and about four-fifths of it remains cultivated. The rest is idle or in permanent vegetation. (Capability unit IVe–4; Loamy Prairie range site; woodland suitability group 3)

Norge-Albion complex, 3 to 5 percent slopes (NxC).—This mapping unit occurs mainly in the northwestern part of the county in close association with Norge soils that have been mapped as separate units. One large area, however, is northwest of Washunga in the eastern part of the county.

Norge loam makes up 35 to 65 percent of the complex, and the Albion soil makes up 20 to 40 percent. About 5 to 10 percent consists of soils that are similar to Albion soil but that lack the sandy clay loam subsoil and are less than 20 inches deep to sand and gravel. The Norge soil has a profile similar to the one described for the series except that its substratum contains more sand. A profile of the Albion soil is described for the Albion series.

In some cultivated fields the surface layer of the soils in this complex has been thinned by water erosion. Small seepy or wet spots occur on the lower part of some slopes near the adjoining bottom lands.

About 35 percent of this mapping unit is cultivated to small grains or sorghum. Crop yields are good to fair. Management is needed that conserves moisture and protects the soil from water erosion. The rest of this complex is in native grass pasture that consists chiefly of big bluestem, little bluestem, and switchgrass. (Capability unit IIIe–2; Norge soil in the Loamy Prairie range site, Albion soil in the Sandy Prairie range site; woodland suitability group 2)

Oil-Waste Land

Oil-waste land (Od) is made up of areas in which liquid oily waste has accumulated. It includes slush pits and the adjacent uplands and bottom lands that have been affected by liquid wastes, mainly salt water and oil. It occurs throughout the county where activity in oilfields has not been controlled. The areas are generally 2 to 5 acres in size, but larger areas occur in the old Three Sands oilfield south of Tonkawa. The upland areas are severely eroded. Soil structure has been destroyed by salts. This land is unsuited to farming, but reclaiming a few small areas is possible. (Capability unit VIIIs–1; not placed in a range site or woodland suitability group)

Owens Series

The Owens series consists of dark-colored, shallow, calcareous soils that occur in the southwestern and north-central parts of the county. Slopes range from 3 to more than 12 percent. These soils developed from weathered olive-gray clay and shale of the Wellington formation.

Owens soils have a grayish-brown, calcareous clay surface layer that is 4 to 7 inches thick and has strong, coarse, granular structure (fig. 10). Many small fragments of grayish to whitish shale occur throughout this layer. Below the surface layer is somewhat massive, partly weathered, light olive-gray clay that begins at an average depth of 5 inches and extends to about 20 inches. Below a depth of 20 inches are olive-gray, unweathered clay and shale that are calcareous. Depth to unweathered clay or shale ranges from 4 to 24 inches.

In places there are bands of escarpments that consist of exposed grayish-colored to olive shale and clay and

***Figure 10.*—Profile of a shallow Owens clay showing the dark-colored, granular surface layer.**

numerous beds of gray mudstone. Thin strata of honeycombed limestone are in many of the upper more sloping areas northeast of Blackwell.

These soils have rapid runoff, slow internal drainage, and very slow permeability. They are droughty because they have limited water-holding capacity.

Owens soils are not suitable for cultivation, and nearly all of the acreage is in pastures that have low carrying capacity. Many of the pastures have been overgrazed and are heavily infested with weeds. In well-managed pastures the native vegetation consists of mixed short and tall grasses, mostly buffalograss, blue grama, big bluestem, and little bluestem.

Owens clay, 3 to 12 percent slopes (OwE).—This soil occupies gentle to strong slopes that are banded by prominent escarpments consisting of gray to bluish-colored shale and numerous beds of gray mudstone. Bare outcrops of bluish-gray shale are common. These escarpments are especially prominent northeast of Blackwell in the uplands adjacent to Bitter Creek. A few areas have slopes greater than 12 percent.

This soil is not suitable for cultivation, because it is shallow, strongly sloping, and very slowly permeable. Water erosion would be severe if this soil were cultivated. Pasture is the main use, and the native vegetation is mostly mid and short grasses. Many pastures have been overgrazed and are heavily infested by weeds. Where the cover of grass is good, carrying capacity is low to fair. Careful mangement, which includes controlled grazing, is needed to keep a dense cover of vigorous plants on this soil. (Capability unit VIe–5; Red Clay Prairie range site; woodland suitability group 4)

Port Series

The Port series consists of deep, loamy, fertile soils on flood plains of the Chikaskia River, Salt Fork Arkansas River, and Deer Creek. These soils formed in alkaline to calcareous, silty, reddish sediments deposited by floodwater.

The surface layer is about 14 inches thick and consists of brown silt loam that has granular structure and is friable when moist. The subsoil extends to a depth of 36 inches and consists of reddish-brown silt loam that also has granular structure. Weak strata of slightly finer textured material commonly are in the subsoil. Below a depth of 3 feet is reddish-brown silty clay loam. In some places at various depths are dark layers that were surface layers until they were buried by sediments. Bands of very slowly permeable clay lie deep in the profile in some places. The surface layer is slightly acid, and the subsoil is neutral to mildly alkaline.

The Port soils are well drained and moderately well drained. Most areas are occasionally flooded for short periods, but along the Chikaskia River, some low, narrow areas are damaged by frequent flooding. Port soils are permeable, absorb moisture well, and have good water-holding capacity.

Most areas of the Port soils that are not frequently flooded are cultivated. These areas are well suited to the crops commonly grown in the county, but in the frequently flooded areas the choice of crops is limited. Tall grasses and trees make up the native vegetation on Port soils.

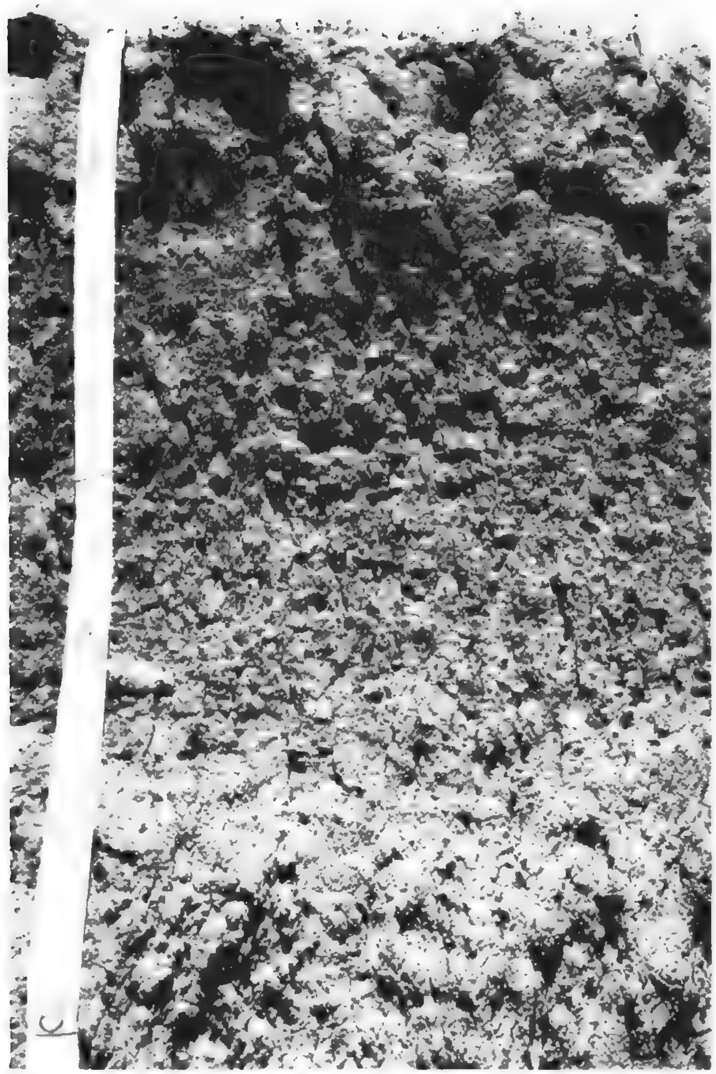

***Figure 11.*—Profile of Port silt loam, a deep, highly productive soil on bottom lands.**

Port silt loam (0 to 1 percent slopes) (Ps).—This deep soil on bottom lands is highly valued for farming (fig. 11). It is easily tilled and is only slightly, if at all, damaged by flooding. Erosion is not likely. This soil is moderately permeable and has medium runoff and internal drainage.

Nearly all of this soil is cultivated. Wheat and alfalfa, the main cash crops, have favorable yields. Response to management is good. (Capability unit IIw–2; Loamy Bottom-land range site; woodland suitability group 1)

Port soils, frequently flooded (0 to 2 percent slopes) (Pf).—These soils generally occupy long, narrow areas on low first bottoms adjacent to the Chikaskia River. They vary considerably from place to place and from time to time because new material is deposited by the frequent floods, which vary in intensity. The surface layer is mainly silt loam but is fine sandy loam and silty clay loam in some places. The profile of these soils is more stratified and generally is finer textured than the profile

described for the Port series. In some areas strata of coarse sand occur below a depth of 3 feet.

These frequently flooded soils are high in natural fertility. They are moderately well drained, but are the least well drained in the lower, more clayey spots.

Bermudagrass and sorghum are grown in some areas. Other areas are used for pecan orchards. Because these soils are frequently flooded, yields are generally much lower than those on Port silt loam. If crops are not damaged by floods, yields are favorable. Bermudagrass pasture is better suited than other crops. Some areas have a dense cover of trees and are excellent for wildlife. (Capability unit Vw–2; Loamy Bottom-land range site; woodland suitability group 2)

Pratt Series

In the Pratt series are deep, dark-colored loamy sands on hummocky uplands. These soils occur mainly in a small area about 5 miles west of Tonkawa. They formed in deep, coarse-textured, water-sorted material that has been reworked by wind and that overlies clay and shale of the Permian redbeds.

The surface layer is about 11 inches thick and consists of grayish-brown loamy fine sand that is single grain or has weak, fine, granular structure. This layer is loose when moist and contains many roots in areas under native grasses. The subsoil, to a depth of 40 inches, is brown, massive loamy fine sand that is loose when moist. Within the subsoil are horizontal bands of slightly darker colored sandy loam that are 1/4 to 1/2 inch thick. These bands are missing below a depth of 40 inches. The surface layer of these soils is medium acid to neutral, but no part of the profile contains free lime.

These soils are low in natural fertility, partly because they are sandy. They contain little organic matter and nitrogen. Unless the content of organic matter is maintained, these soils become droughty and less fertile. Wind erosion may be a serious hazard if the surface layer is not protected. Water erosion is not a serious hazard, because water is absorbed rapidly and runoff is slight or none.

About 60 percent of the acreage of Pratt soils is in native pastures of bluestem. Most of the cultivated acreage is used for small grains and sorghum. Crop yields are moderately low or low, depending on the rainfall during the growing season, the fertility of the soil, and the degree of wind erosion.

Pratt loamy fine sand, hummocky (PtC).—This soil occupies only a small acreage in Kay County. Slopes are 3 to 8 percent. Included in the areas mapped as this soil are areas of Shellabarger soils, which make up about 5 percent of the mapping unit.

In cultivated areas practices are needed to control wind erosion and to maintain fertility. Unless a protective cropping system is used, this soil blows and drifts. The severity of wind erosion depends mainly on the amount of ground cover. Winnowing and drifting are common in unprotected fields. The loose sand makes tillage and use of power equipment difficult. (Capability unit IVe–6; Deep Sand range site; woodland suitability group 2)

Reinach Series

The Reinach series consists of deep, friable soils that formed in alkaline to calcareous loam or sandy loam on terraces or second bottoms. These soils generally occupy nearly level to sloping, natural levees on the flood plain of the Chikaskia River or are on low terraces along the Salt Fork Arkansas River. They are 5 to 15 feet higher than the associated Yahola soils. In places the Reinach soils adjoin the rivers.

The surface layer is brown loam about 17 inches thick. It has weak and moderate, fine, granular structure and is very friable when moist and soft when dry. Underlying the surface layer is 10 to 20 inches of neutral, brown loam. This layer is much like the layer above except that it is more reddish. Below a depth of 30 inches is yellowish-red loam that has weak, fine, granular structure. This material is very friable when moist, alkaline to calcareous, and uniform in color and texture to a depth of 4 feet or more. In small areas near the Salt Fork Arkansas River, these soils have a very fine sandy loam surface layer.

Reinach soils are well drained and have good water-holding capacity and moderate permeability. Natural fertility is high, and tillage is easy. In some years wind erosion may be a hazard, but under good management it can be easily controlled. If they are not well managed, the more sloping Reinach soils are subject to severe water erosion.

Almost all of the acreage of these soils is cultivated. All crops adapted to the county produce favorable yields. The cash crops commonly grown are small grains and alfalfa. Crops on these soils respond well to intensive management. Some farms in the county are made up entirely of Reinach soils.

Reinach loam, 0 to 1 percent slopes (RcA).—This extensive soil is deep and permeable. It occupies weakly convex slopes. Included in areas mapped as this soil are small areas of darker colored, finer textured Port silt loam. These included areas make up less than 5 percent of this mapping unit.

This is one of the most important soils in the county for farming. It is suited to all crops commonly grown. Productivity is high and is much easier to maintain than that of most other soils of the county. (Capability unit I–1; Loamy Bottom-land range site; woodland suitability group 1)

Reinach loam, 3 to 8 percent slopes (RcD).—This soil occupies flood plains on low terraces of the Salt Fork Arkansas and Chikaskia Rivers. It is on breaking slopes that separate low areas of bottom land from higher ones. These breaks, normally only 100 to 200 feet wide, distinguish this soil from other soils in the landscape. Although slopes range from 3 to more than 8 percent, they average about 6 percent. This loamy soil has a lighter colored, thinner surface layer than the soil described for the series and, in many places, a sandier substratum. Water erosion has removed 20 to 50 percent of the original surface layer. After rains of high intensity, small rills appear, but they can be removed by tillage.

Included in areas mapped as this soil are areas of finer textured Brewer soils and of soils similar to the Port soils. These included soils make up 5 to 10 percent

of the mapping unit. Also included are some old arable, U-shaped channels of meandering streams.

Farming is difficult on this soil because the hazard of erosion is moderate and narrow strongly sloping bands hinder the use of large farm machines. Generally, the same crops are grown on this soil as are grown on the surrounding Reinach loam, 0 to 1 percent slopes. Some areas have been planted to bermudagrass and are providing large amounts of forage of excellent quality. (Capability unit IVe-8; Loamy Bottom-land range site; woodland suitability group 2)

Renfrow Series

The Renfrow series consists of deep, dark-brown soils that have a very slowly permeable subsoil. These soils are in small scattered areas on uplands throughout the central and western parts of the county. They formed from clay and shale of the Permian redbeds.

The surface layer, about 6 inches thick, is brown silt loam that has granular structure and is friable when moist. It grades to a subsurface layer of reddish-brown clay loam about 4 to 7 inches thick. At an average depth of 12 inches, there is a reddish-brown, blocky clay subsoil (fig. 12). The clay in the lower part of the subsoil is more compact than that above and contains a few concretions of calcium carbonate. Below a depth of 30 inches is calcareous, massive clay. The surface layer is slightly acid, and the lower part of the subsoil is alkaline or calcareous.

These soils are well drained. They are subject to accelerated erosion and are somewhat droughty because of their very slowly permeable subsoil and rapid to medium runoff. These soils contain a fair to good supply of plant nutrients.

Most of the areas of Renfrow soils are used for small grains, but a considerable acreage is in pasture consisting largely of short grasses. Crop yields are fair to good in years of ample moisture.

In Kay County Renfrow soils are mapped only in complexes with Kirkland soils.

Renfrow-Kirkland silt loams, 3 to 5 percent slopes (RkC).—These soils occur in an intricate pattern and are mapped together as one unit. They occur in small areas throughout the central and western parts of the county and in larger areas in the southwestern part. Renfrow silt loam makes up 40 to 70 percent of the mapping unit, and the Kirkland silt loam makes up 30 to 50 percent. Both the Renfrow and the Kirkland soils have a profile like the ones described for their respective series. Included in mapping were areas of Vernon clay loam that make up about 5 percent of this mapping unit.

Most of this mapping unit is used for pasture. In cultivated areas intensive management is required to reduce erosion. Controlled grazing of native pastures also is needed so that grasses reseed each year. Many pastures have been overgrazed, and in these only short grasses and weeds remain. (Capability unit IVe-7; Claypan Prairie range site; woodland suitability group 3)

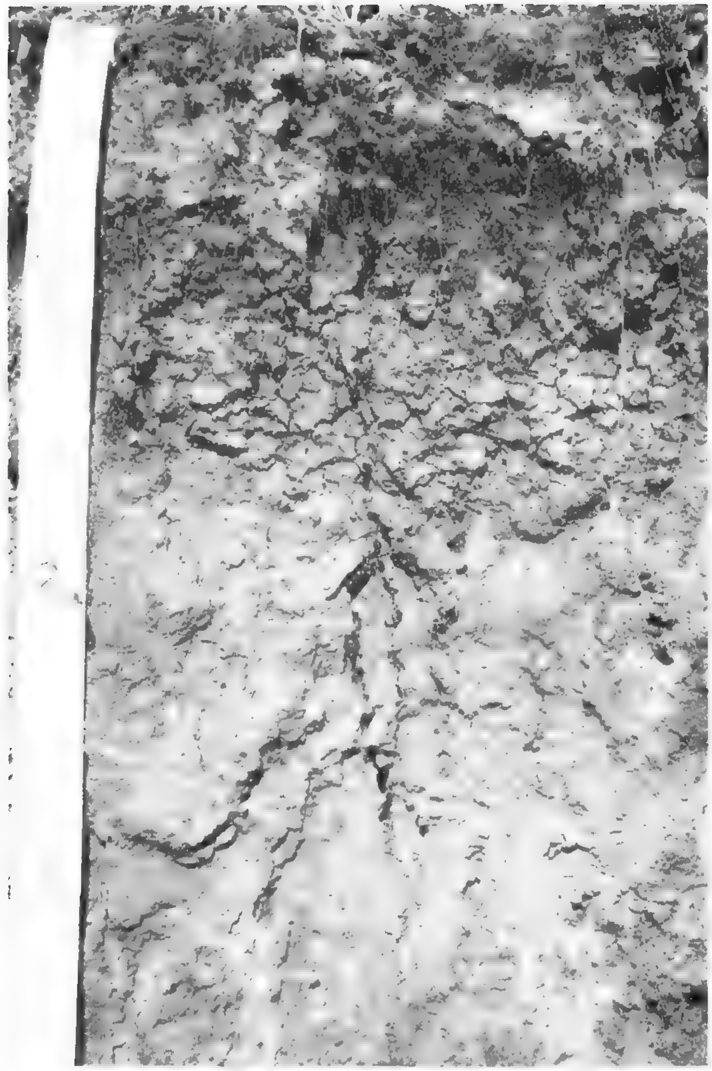

Figure 12.—**Profile of Renfrow silt loam, 3 to 5 percent slopes, showing the blocky clay subsoil at a depth of 12 inches. The lighter colored areas, at a depth of about 36 inches, are lime concretions.**

Sand Dunes, Lincoln Material

Sand dunes, Lincoln material (Sa) occupies stabilized sand dunes on the flood plains of the Arkansas and Salt Fork Arkansas Rivers. It nomally occurs in narrow bands that parallel the rivers. These bands are between areas of Yahola, Lincoln, and Carr soils. The sand dunes form choppy relief and rise as much as 20 feet but are generally only 5 to 10 feet high. Slopes range from 2 to 20 percent, but the dominant range is 3 to 12 percent.

The surface layer is neutral to calcareous loamy fine sand to sand about 5 to 10 inches thick. It ranges from brown to grayish brown but normally is darker in areas along the Arkansas River than in areas along the Salt Fork Arkansas River. The substratum is loose, alkaline or calcareous sands.

These sand dunes are excessively drained, are very rapidly permeable, and have low water-holding capacity. The higher sand dunes are not flooded, though associated Yahola, Lincoln, and Carr soils are flooded at times.

All of this land is in native vegetation and is used for range. The sand dunes are generally stabilized by plum thickets, sand bluestem, switchgrass, and some trees.

When rainfall is ample, the production of desirable forage is fair, but in most seasons production is low. (Capability unit VIs–1; Dune range site; woodland suitability group 4)

Shellabarger Series

The Shellabarger series consists of deep soils that have a sandy clay loam subsoil. These soils occupy very gently sloping to sloping uplands, mainly northwest of Washunga in the eastern part of the county. In other parts of the county, they occur in small areas within a few miles of the major rivers. They developed in slightly acid, sandy material that was laid down by water and then partly reworked by wind.

The surface layer is very dark grayish-brown to dark-brown fine sandy loam about 12 inches thick. Between depths of 12 to 16 inches is a brown subsurface layer that is slightly more clayey than the surface layer. The subsurface layer has granular structure and is friable when moist. The subsoil, about 26 inches thick, is brown to reddish-brown sandy clay loam that has subangular blocky structure. Below a depth of 42 inches is yellowish-red sandy loam that has weak granular structure. Shellabarger soils are medium acid in the upper part of the profile and medium acid to neutral in the lower part.

Shellabarger soils are well drained. They take in water well and are moderately high in plant nutrients. In cultivated areas, however, they are susceptible to wind and water erosion. The hazard of water erosion increases as the degree and length of the slopes increase.

Most of the acreage of these soils is cultivated to many kinds of crops. Yields are favorable. Small grains are the principal crops, but these soils are also well suited to vegetables and other truck crops. Response of crops to good management is excellent to high. In native pastures the vegetation consists of bluestem, switchgrass, indiangrass, and a few scattered oak trees in some areas.

Shellabarger fine sandy loam, 1 to 3 percent slopes (ShB).—This soil occurs on very gentle slopes of divides that are next to more sloping areas of Norge and Vanoss soils. In cultivated fields the surface layer of this soil is slightly darker and thicker than that of the more sloping Shellabarger soils. In some small areas west of Tonkawa, small, waterworn pebbles occur in the profile. Included in the areas mapped as this soil are small areas that have a loamy fine sand surface layer. These are former areas of Shellabarger fine sandy loam that have been eroded by wind.

Most all of this soil is cultivated. It is easy to till and is suited to all crops grown in the county. It is less susceptible to water erosion than more sloping Shellabarger soils and slightly more productive. (Capability unit IIe–2; Sandy Prairie range site; woodland suitability group 1)

Shellabarger fine sandy loam, 3 to 5 percent slopes (ShC).—This soil is on uniform uplands in close association with other Shellabarger soils and with soils of the Dougherty-Eufaula complex. Because runoff is moderate to rapid, the surface layer has been thinned slightly by water erosion in places. Included in areas mapped as this soil are spots that have a loamy fine sand surface layer. In these spots wind erosion has been more severe than normal.

About three-fourths of this soil is cultivated, and the rest is meadow and pasture. Small grains, tame pasture, and truck crops are the principal crops. This soil is easily worked. Crops respond well to improved management and produce favorable yields. (Capability unit IIIe–4; Sandy Prairie range site; woodland suitability group 2)

Shellabarger fine sandy loam, 5 to 8 percent slopes (ShD).—Most of this soil is on uniform sloping uplands east of Newkirk beyond the Arkansas River. Much of the acreage is narrow bands above the heads of entrenched drainageways.

Runoff and erosion are the main hazards in cultivated areas. In most cultivated fields, erosion has thinned the surface layer so that it is thinner than the one described for the series. In about 25 to 50 percent of the cultivated acreage, subsoil material has been mixed into the surface layer. Included in mapping were areas that have a loamy fine sand surface layer. These included areas adjoin Dougherty-Eufaula complexes.

Most of this soil is in native grass. In cultivated areas the crops are about the same as those on the less sloping Shellabarger soils.

Because the hazards of wind and water erosion are moderately severe, the practices needed are good management of crop residue, use of a suitable cropping system, terracing, and contour farming. Varying the depth of tillage reduces the formation of a plowpan. Grazing is good on pasture. (Capability unit IVe–5; Sandy Prairie range site; woodland suitability group 3)

Sogn Series

In the Sogn series are very shallow soils on uplands in the more sloping eastern part of the county, which is commonly called the Bluestem Hills. These soils developed from weathered limestone and calcareous shale.

The surface layer, about 9 inches thick, is generally very dark gray silty clay loam that has strong, medium, granular structure. It contains fragments of partly weathered limestone. An abrupt, irregular boundary separates the surface layer from the underlying limestone bedrock. Crevices extend deep in the limestone. In spots these crevices are filled with dark-colored material from the surface layer. This material reaches to a depth of 15 inches in the cracks. A few grass roots follow the cracks to a depth of several feet. The surface layer of Sogn soils ranges from silty clay loam to stony clay loam or silt loam in texture and from very dark gray to very dark brown in color. Rock crops out at the surface in places, and fragments of limestone are generally on the surface and throughout the profile.

Sogn soils are high in natural fertility. They are well drained, and the water table is never above the substratum. Infiltration is moderate to rapid, and internal drainage is rapid. The water-holding capacity is limited because the soil material is thin over bedrock. Consequently, these soils are droughty.

These very shallow, stony, droughty soils are not suitable for cultivation. They are suited to native grasses. Big bluestem grows where these soils are deepest, and short grasses grow where the soils are very shallow.

Sogn soils, 1 to 3 percent slopes (SnB).—These soils occur in small very gently sloping areas above the prom-

inent limestone escarpments that are in the Sogn-Summit complex. In the extreme northeastern corner of the county, fragments of chert are common on these soils. In about 5 to 10 percent of the acreage west of the Arkansas River, the surface layer is less grayish than the very shallow profile described for the Sogn series.

These soils are used for pasture consisting of native grasses, but they are not productive during periods of dry weather. Management is difficult. To control erosion, a permanent cover of grass is needed, as well as protection from overgrazing. Good pastures can be maintained on these soils in periods of normal or high rainfall. (Capability unit VIIs–1; Very Shallow range site; woodland suitability group 4)

Sogn-Summit complex, 5 to 20 percent slopes (SsF).—This complex occupies prominent limestone escarpments and rocky colluvial foot slopes in the more dissected eastern part of the county. It is part of the native grass prairie of the Bluestem Hills. The soils in this mapping unit occur in such an intricate pattern that it was not practical to show them separately on the soil map. Although the proportions of the soils vary from place to place, this complex generally is about 60 percent Sogn soils, 30 percent Summit silty clay loam, and 10 percent a shallow soil that developed in beds of clay interbedded with limestone. A profile typical of the Summit soil is described for the Summit series.

In this mapping unit limestone exposures are numerous, the deep to moderately deep soils are intermingled with the very shallow soils, slopes are gentle to precipitous, and gullies are deep. The limestone exposures are continuous on broken ledges, and in many places there is a vertical drop of 3 to 10 feet. In most areas these ledges are bands on the upper part of the slope that wind around the slope break at about the same level. Below the limestone ledges, Summit soils are intermingled with Sogn soils. In these areas the underlying material is unweathered reddish-brown to grayish clay. As the geologic erosion continues, many of the limestone ledges slough off and tumble downward. Later they become partly covered with colluvial soil material. Because slopes are moderately steep, narrow active gullies occur in many places below the ledges.

This extensive complex occurs on almost every ranch in the eastern part of the county. All of the acreage is native rangeland. The vegetation is mostly native grasses, but some trees grow on the steeper slopes adjacent to the Arkansas River and smaller streams. Grazing is poor in areas where the soils are very shallow but is good or excellent where the soils are deeper. Large limestone quarries are in areas of this mapping unit. (Capability unit VIIs–1; Sogn soils in the Very Shallow range site and woodland suitability group 4, and Summit soils in the Loamy Prairie range site and woodland suitability group 3)

Summit Series

The Summit soils are deep and moderately deep, moderately fine textured and fine textured soils on uplands, mainly in the more dissected northeastern part of the county. Gently sloping Summit soils also occur in the north-central and southwestern parts of the county. These soils developed in residuum from limestone interbedded with dark-colored shale and clay.

The surface layer is 8 to 18 inches thick and consists of very dark gray to very dark grayish-brown silty clay loam that is friable and medium acid or slightly acid. It has strong, coarse and medium, granular structure. The upper part of the subsoil is 7 to 15 inches thick and consists of very dark grayish-brown heavy silty clay loam that is very firm when moist. It has moderate, medium, blocky structure. Below a depth of about 23 inches, the subsoil is brown, blocky clay that contains a few iron concretions and some chert fragments. At a depth of about 32 inches, the soil material is brown, massive clay that contains small fragments of chert and partly weathered limestone. The depth to bedrock ranges from 24 inches to more than 5 feet.

These soils are well drained in most places but are excessively drained in sloping areas. They are slowly and very slowly permeable, have moderate capacity to absorb water, and tend to be somewhat droughty in extended dry periods. These soils contain a good supply of organic matter in areas that are not eroded. Unless management is good, accelerated water erosion is likely.

Most of the acreage of Summit soils is cultivated, mainly to small grains, alfalfa, and sorghums. Crop yields are favorable. In native pastures stands of big and little bluestems are good and provide excellent forage.

Summit silty clay loam, 1 to 3 percent slopes (SuB).—This soil occurs mainly in rather large, uniform, very gently sloping areas. A large area of this kind is about 11 miles east of Newkirk. Several small areas, with a total acreage of less than 50 acres, have slopes of slightly less than 1 percent. The profile of this soil is similar to the one described for the series.

In rangeland are low swales or old buffalo wallows that remain wet for several days after heavy rains. In some cultivated fields, erosion has slightly thinned the surface layer and a few small slickspots occur.

Much of this soil is cultivated. Small grains, sorghum, and alfalfa are the chief crops. Although this soil is naturally productive, many farmers have profited by adding nitrogen and phosphate. Controlling water erosion and maintaining soil structure and fertility are practices that help to insure favorable yields continuously. Erosion is reduced by constructing terraces, managing crop residue, and seeding legumes. In grassland, protection from overgrazing is needed so that desirable native grasses grow more vigorously. (Capability unit IIe–1; Loamy Prairie range site; woodland suitability group 2)

Summit silty clay loam, 3 to 5 percent slopes (SuC).—This soil occupies gently sloping uplands, mainly on colluvial foot slopes. It lies below Sogn-Summit complex, 5 to 20 percent slopes, east of the Arkansas River and below Owens clay, 3 to 12 percent slopes, in the north-central and southwestern parts of the county.

In some areas, especially in slightly eroded cultivated fields, the surface layer is thinner than typical. Limestone is near the surface in some places on the colluvial slopes. In areas near Owens soils, the color of the substratum is olive gray. A few slickspots occur in cultivated fields. Much of this soil is still in native bluestem pasture. Yields of cultivated crops are favorable, but slightly lower than those on the very gently sloping

Summit soils. (Capability unit IIIe-2; Loamy Prairie range site; woodland suitability group 3)

Summit silty clay, 3 to 5 percent slopes, eroded (SyC2).—This soil is mostly on colluvial foot slopes below the adjoining Sogn-Summit complex, 5 to 20 percent slopes, or in areas of strongly sloping Owens soils. In places much of the granular surface layer of this Summit soil is washed away by the water rushing down from higher slopes. This soil has a spotty appearance because erosion is not uniform. It has a thinner, more clayey surface layer than the soil described for the Summit series. In some small areas the subsoil is exposed. In many places tillage has mixed subsoil material with the original surface layer. A few small slickspots occur in the more eroded areas.

Surface runoff is rapid. Fertility and the supply of organic matter are moderately low. Response of crops to good management, including fertilization, is poor in areas where the subsoil is exposed.

About 60 percent of this soil is cultivated to small grains. The rest is abandoned cropland. Some areas have been reseeded to native grasses, but in many areas the stand of grass, dominantly three-awn, is poor. (Capability unit IIIe-3; Loamy Prairie range site; woodland suitability group 3)

Tabler Series

The Tabler series consists of deep, dark-colored soils that have very slowly permeable clay subsoil and are commonly called claypan soils. These soils are in slight depressions or nearly level areas in the central and western parts of the county. Large areas are west of Ponca City and west of Blackwell. These soils formed in calcareous clay to heavy clay loam alluvium or in residuum from underlying Permian clay and shale.

The surface layer is dark-gray silt loam that averages 8 to 10 inches in thickness. It has granular structure and is medium acid to slightly acid. The boundary between the silt loam surface layer and the clay subsoil is abrupt (fig. 13). The subsoil, about 24 to 30 inches thick, is very dark gray clay that has blocky structure when dry but appears massive when moist. Below a depth of about 3 feet is lighter colored, less dense, brown silty clay that is mottled with gray and dark yellowish brown. The upper part of the subsoil is slightly acid to neutral, and the lower part is alkaline. A few small concretions of calcium carbonate normally occur at a depth of about 32 inches.

Tabler soils have slow runoff and internal drainage and are wet for short but significant periods. Periods of wetness are shortest in a few places where the slopes are less than 1 percent. Soil blowing is a temporary hazard when a surface crust forms after intense rains. Tabler soils have moderately high natural fertility.

These soils are well suited to small grains and grain sorghum. Wheat is the main cash crop. The main limitation to production is lack of sufficient moisture. In small pastures or meadows, the native vegetation is a mixture of tall and short grasses.

Tabler silt loam, 0 to 1 percent slopes (TaA).—This extensive soil is on flat uplands, normally in large areas. Its clay subsoil is slowly permeable. Included in mapping are a few small areas of Tabler soil that have a clay loam surface layer. Other inclusions are areas of Kirkland silt loam, 1 to 3 percent slopes, of Waurika silt loam, and of Bethany silt loam, 0 to 1 percent slopes.

***Figure 13.*—Profile of Tabler silt loam, 0 to 1 percent slopes, showing the abrupt boundary between the surface layer and the subsoil.**

The larger areas of this Tabler soil are well suited to the use of modern farm equipment. About 95 percent of this soil is cultivated, and the rest is in native grasses. Crop yields are good. Water erosion is a hazard in the more sloping areas and on long uniform slopes that are less than 1 percent. Returning all crop residue to the soil, tilling at a minimum, and seeding legumes are practices that help to control wind erosion and water erosion by increasing the intake of water and reducing surface crusting. (Capability unit IIs-1; Claypan Prairie range site; woodland suitability group 3)

Vanoss Series

The Vanoss series consists of deep, brown, friable, loamy soils. These soils are on level to sloping high terraces, within a few miles of rivers. Vanoss soils developed in unconsolidated, light-colored, loamy deposits that contain a large amount of weatherable minerals. The vegetation

was tall native grasses, mostly bluestem and indiangrass.

The surface layer is about 16 inches thick and consists of brown silt loam that is friable, has a granular structure, and is easy to till. The subsoil, 22 inches thick, is brown silty clay loam that has subangular blocky structure and crumbles readily when crushed. It is permeable to roots, air, and water and has high water-holding capacity. Below a depth of about 38 inches, the silty clay loam soil material is lighter colored than that above and ranges from brown to reddish brown.

These soils are well drained and fertile. Their permeable subsoil readily gives up moisture to plants and enables them to withstand drought much better than crops on the finer textured claypan soils. Crops on Vanoss soils respond to additions of fertilizer, use of legumes, and other management. Water erosion is a hazard on the more sloping Vanoss soils. Seasonal blowing is also a hazard, especially where the surface crusts after heavy rains.

Vanoss soils are among the best soils of the terraces and uplands in the county for general crops. Most of their acreage is cultivated to small grains, alfalfa, sorghum, and minor crops. Yields are continuously favorable if management is good. Stands of big bluestem and little bluestem are excellent if they are not overgrazed.

Vanoss silt loam, 0 to 1 percent slopes (VaA).—This soil occurs on level to weakly concave, uniform, high terraces of the Arkansas and Salt Fork Arkansas Rivers. In most places the profile of this soil is similar to the one described for the Vanoss series, but in some areas along the Salt Fork Arkansas River, the profile is slightly less silty.

This soil is excellent for farming. It is easily worked. Runoff is slow, infiltration is good, and there is no or only slight erosion.

Except for small areas south of Ponca City, nearly all of the acreage is cultivated. (Capability unit I–2; Loamy Prairie range site; woodland suitability group 1)

Vanoss silt loam, 1 to 3 percent slopes (VaB).—This soil borders nearly level Vanoss soils on the more uniform less sloping areas and, in places, occupies very gently convex crests of ridges above the more sloping Vanoss soils. The largest area is an intermittent belt north of the Salt Fork Arkansas River. This belt is 1 to 2 miles wide. It extends from the Grant County line through Tonkawa to a point south of Ponca City. Included in mapping, along the Salt Fork Arkansas River, were areas in which the surface layer is more sandy than normal.

The surface layer of this soil is slightly lighter colored than that of the soil described for the Vanoss series and is generally 2 to 4 inches thinner. In areas near or in natural drainageways, erosion has thinned the surface layer and has formed a few rills.

Although runoff is medium and much of the rainfall is absorbed by the soil, terraces and contour farming are needed in many areas to reduce the loss of soil. Wind erosion is a hazard in some years.

Most of this soil is cultivated. Yields of crops are average or above average. (Capability unit IIe–1; Loamy Prairie range site; woodland suitability group 1)

Vanoss silt loam, 3 to 5 percent slopes (VaC).—This soil is on old stream terraces that have a convex surface. Most of it is in high positions, mainly above the Arkansas River.

This gently sloping soil has a thinner surface layer and is slightly darker than the soil described for the Vanoss series, and generally it has a less clayey subsoil. The subsoil is light clay loam in most places. In cultivated fields water erosion has removed 20 to 40 percent of the surface layer. Erosion is most noticeable around the heads of drainageways where water concentrates.

About four-fifths of this soil is cultivated, and the rest is in native grass. Partly because water erosion is a hazard, small grains, mainly winter wheat, are the main crops grown. (Capability unit IIIe–2; Loamy Prairie range site; woodland suitability group 2)

Vanoss silt loam, 5 to 8 percent slopes (VaD).—This soil occupies the convex slopes of old stream terraces that are high above the Arkansas River and other large streams. It occurs closely with Vanoss silt loam, 3 to 5 percent slopes, and other Vanoss soils, and it has a thinner surface layer than those soils. Sheet erosion and gully erosion have removed one-fourth to one-half of the surface layer from most cultivated areas, but deep gullies are few. This soil is susceptible to severe gullying.

About one-half of this soil is cultivated. In cultivated fields terraces and contour farming are needed to reduce loss of soil and to help prevent deep gullying. On the stronger short slopes, permanent cover is a better use than cultivated crops because it protects against gully erosion. In most pastures big bluestem and little bluestem grow in good stands. (Capability unit IVe–3; Loamy Prairie range site; woodland suitability group 3)

Vernon Series

The Vernon soils are shallow (fig. 14) over reddish-brown, calcareous, compact clay of Permian age. These soils occupy gentle to strong slopes along the breaks of valleys, mostly in the southwestern part of the county.

The surface layer is reddish-brown, calcareous, granular heavy clay loam that contains a few small fragments of partly weathered siltstone and shale. This layer is about 6 inches thick in cultivated fields and about 8 inches thick in native pastures. Underlying the surface layer is reddish-brown clay about 4 to 12 inches thick. This layer is very slowly permeable to water. It grades to reddish-brown, calcareous beds of clay that are essentially unaltered. The clay beds are generally at a depth of 10 to 20 inches in the less sloping Vernon soils, but they are commonly exposed at the surface of strong slopes.

Vernon soils have rapid runoff and are highly susceptible to erosion. They are droughty because a large amount of water runs off and the available water-holding capacity is low.

Most of the acreage of Vernon soils is used for pasture. Small grains, the main cultivated crops, produce moderately low yields. Many of the pastures are overgrazed. The native plants in the better pastures consists chiefly of buffalograss, grama, and some bluestem.

Vernon clay loam, 3 to 5 percent slopes (VeC).—This shallow soil occupies uplands, normally below broken areas of Vernon soils, 5 to 12 percent slopes. It has a profile similar to the one described for the series. The clay loam surface layer is underlain by a very slowly

Figure 14.—**Profile of shallow Vernon soils, 5 to 12 percent slopes.**

permeable subsoil. Included in areas mapped as this soil are some small areas that have a clay surface layer. In cultivated fields the surface layer has been thinned by erosion.

This soil is not well suited to cultivation, but about 70 percent is cultivated. Small grains are the main crops. Practices that reduce erosion, conserve moisture, and maintain fertility are farming on terraces and on the contour, managing crop residue well, and using soil-improving crops. Controlling grazing lessens the increase of undesirable grasses and weeds. (Capability unit IVe-1; Red Clay Prairie range site; woodland suitability group 3)

Vernon soils, 5 to 12 percent slopes (VsE).—This soil is in the southwestern part of the county in rough, broken areas characterized by escarpments and drainageways.

In the deeper areas of these soils, the profile is similar to the one described for the series. In many areas, however, raw clay and shale are exposed at the surface. Also, the surface layer ranges from silt loam to clay loam or clay in texture and from 5 to 20 inches in thickness. The surface layer is underlain by reddish-brown raw clay and shale. Clay and shale crop out, mainly around the rim of escarpments. Slopes exceed 12 percent on some escarpments. Some areas are capped by a thin bed of reddish sandstone, and other areas are marked by small outcrops of blue and gray shale.

Because Vernon soils are shallow, strongly sloping, and susceptible to erosion, they are not cultivated. Pasture is the most economical use, but even if management is good, forage suitable for grazing is difficult to maintain. Among the best suited grasses are sideoats grama, blue grama, and little bluestem. Heavily grazed areas are infested with annual grasses, hairy tridens, and three-awn. By preventing overgrazing and using other good practices, forage is increased, rapid runoff is slowed, and erosion is reduced. (Capability unit VIe-5; Red Clay Prairie range site; woodland suitability group 4)

Waurika Series

The soils in the Waurika series are on uplands in level to slightly concave areas, where they occur mainly with the Tabler soils. The largest areas are between Ponca City and Tonkawa. Waurika soils have a clay subsoil that absorbs water very slowly. In most places these soils developed in calcareous clay to heavy clay loam alluvium, but in some areas they developed in residuum from the underlying clay and shale of the Wellington formation.

The surface layer is friable silt loam 8 to 12 inches thick. The upper part is gray and has weak granular structure, and the lower 2 to 5 inches is light gray and structureless. An abrupt boundary separates the surface layer and the subsoil.

The subsoil is dark-gray silty clay that extends to a depth of 32 inches. It has blocky structure. The surface of the peds are shiny because it is covered with a colloidal varnish called clay skins. Water moves very slowly through the subsoil. Because the clay in the subsoil expands when it is wet and contracts when it dries, these soils crack in many places during extremely dry periods. The cracks close when it rains and the clay is again moistened.

The layer between depths of 32 and 36 inches is much like the layer above except that it contains small black concretions. Between depths of 36 and 42 inches is dark-gray silty clay containing concretions of calcium carbonate. The underlying substratum is at a depth of 4 or 5 feet. It is less clayey than the subsoil and is commonly mottled with dark yellowish brown to shades of gray. The surface layer is strongly acid to slightly acid. The subsoil is neutral to slightly acid in the uppermost few inches and is alkaline in the lower part.

The Waurika soils are moderately high in natural fertility. They are somewhat poorly drained. After heavy rains, surface water remains for some time in the level and depressional areas. Most of the water remains on the surface until it evaporates because little water passes through the clay subsoil. Water erosion is not likely on these soils, but wind erosion is a temporary hazard when the surface crusts after heavy rains.

These soils are suited to small grains and grain sorghum. Good stands of small grains, especially wheat, are difficult to establish because water often covers the surface. But in summer, grain sorghum is frequently damaged because not enough water is available. These soils are difficult to manage, for they are droughty in summer and may have excessive water on the surface at other times. Available moisture can be increased in these soils by seeding sweetclover, alfalfa, and other deep-rooted legumes. The roots of these plants loosen these soils and allow more water to penetrate.

Waurika silt loam (0 to 1 percent slopes) (Wa).—This somewhat poorly drained, light-colored soil occupies level depressions in the central and western parts of the county. It occurs mainly within areas of Tabler silt loam, but, on the high terraces of the Arkansas and Salt Fork Arkansas Rivers, it occurs within areas of Vanoss soils.

In the depressions this soil stays wet for a week or 10 days longer than the associated Tabler silt loam, 0 to 1 percent slopes. The depressions are drained through a system of shallow open ditches that is locally called turtle-back drainage.

Most of this soil is cultivated to small grains and grain sorghum, but a few areas are in pasture of tall and short native grasses. Crop yields are fairly favorable, but they vary as the rainfall varies. Excess moisture or the lack of moisture seriously limits the production of crops. The very slowly permeable clay subsoil has low available moisture capacity. Practices that prevent surface crusting and increase the intake of water are plowing under crop residue, tilling at a minimum, and seeding legumes. (Capability unit IIs–2; Claypan Prairie range site; woodland suitability group 3)

Yahola Series

Soils of the Yahola series are deep, light colored, and loamy to sandy. They are along the Salt Fork Arkansas and Chikaskia Rivers on low bottom lands that are subject to flooding. These soils developed in alkaline to calcareous stratified sediments that were recently deposited. Fresh material is deposited during the recurrent floods.

These soils generally have a brown fine sandy loam surface layer and a light-brown loamy fine sand subsurface layer. Together these layers are about 23 inches thick. They are friable when moist. The upper part of the underlying substratum is reddish-brown, calcareous loam that is stratified with sandier and more clayey material. This layer has moderate, medium, granular structure and is friable when moist. Below a depth of 35 inches is calcareous, yellowish-red, structureless loamy fine sand that is loose when dry.

Yahola soils absorb water readily and have rapid to moderate internal drainage. The depth to the water table is commonly 5 to 20 feet. These soils are flooded at intervals that range from 2 to 10 years, but the frequency of floods on the low bottom lands along the Salt Fork Arkansas River has been reduced by the construction of the Great Salt Plains Reservoir. This reservoir is upriver in Alfalfa County. Soil blowing is common on these soils, especially where the surface layer is loamy fine sand. These soils are easy to till.

Most of the acreage is cultivated. In some places all crops common in the county can be grown, but the choice of crops is limited in areas where the content of organic matter is low and flooding is likely. In permanent pastures the vegetation is mixed and consists of tall grasses and scatterings of cottonwood, elm, and hackberry.

Yahola fine sandy loam (0 to 1 percent slopes) (Ya).—This soil generally has a calcareous fine sandy loam surface layer and stratified sandy to clayey lower horizons like those in the profile described for the Yahola series, but it is more sandy in higher areas than it is in low swalelike areas. Included in mapping were a few small areas of Yahola loamy fine sand. Inclusions of Miller clay occur in some of the swalelike areas.

Wind erosion is generally the main limitation in cultivated areas, but flooding is also a hazard. During severe floods, some areas of this soil are deeply scoured and others are covered by deep deposits of sandy material.

About four-fifths of this soil is cultivated. The rest, mostly narrow, parallel bands separated by Sand dunes, Lincoln material, is used for pasture. (Capability unit IIw–3; Loamy Bottom-land range site; woodland suitability group 1)

Yahola loamy fine sand (0 to 2 percent slopes) (Yf).—This soil is on level to very gently undulating areas on flood bottoms of the Salt Fork Arkansas River. It occurs with Yahola fine sandy loam and Sand dunes, Lincoln material.

This soil is more sandy and has a thinner profile than the soils described for the Yahola series. The surface layer is a structureless loamy fine sand that is alkaline to calcareous. It is underlain by 5 to 12 inches of reddish-brown loamy fine sand that is very friable when moist. Below a depth of 12 inches is the substratum consisting of reddish-yellow loamy fine sand. It is structureless and strongly calcareous. Thin bands of reddish, finer textured material are common in the substratum.

This soil is susceptible to severe wind erosion. It has low water-holding capacity and is somewhat droughty. The surface layer contains only a small amount of organic matter.

About one-half of this soil is cropped to small grains, and the rest is in native pasture. Productivity is moderate to low. Essential on this soil are crops that produce large amounts of crop residue. (Capability unit IIIs–1; Sandy Bottom-land range site; woodland suitability group 2)

Use and Management of Soils

The soils of Kay County are used extensively for cultivated crops, pasture, and native range. This section explains how the soils may be used for these main purposes and also for windbreaks and post lots, for wildlife, and in the building of highways, farm ponds, and other engineering structures. Also given are predicted yields of the principal crops under two levels of management.

The management of crops and pasture, of range, and of windbreaks and post lots is discussed by groups of soils. To determine the soils in each of these groups, refer to the "Guide to Mapping Units" at the back of this survey.

This section is a general guide for managing soils; it does not suggest specific management for individual soils.

Management of Soils for Cultivated Crops and Pasture [2]

The main objectives of good management in this county are control of erosion, maintenance of the supply of organic matter, improvement or maintenance of tilth,

[2] By M. D. GAMBLE, conservation agronomist, Soil Conservation Service.

and conservation of moisture. In some places surface crusting also requires attention.

The most effective way of controlling erosion on the soils in this county is using a carefully chosen set of practices. Suitable practices are growing a winter cover crop; keeping crop residue on or near the surface; practicing minimum tillage; stripcropping; growing grasses, legumes, or both in a long-term rotation with tilled crops; constructing terraces; farming on the contour; keeping waterways in sod; applying lime and fertilizer where needed; and growing tame pasture plants.

The cropping system selected has much to do with the success of management. Under a good system, the soil can be kept in good tilth and protected from erosion; and weeds, insects, and plant diseases can be controlled. Growing crops that produce a large amount of residue is also part of a good cropping system. Crops other than legumes can be used for this purpose. If small grains are grown and the straw is left as residue, it is frequently necessary to add nitrogen to hasten the decomposition of the straw. This, however, is not a substitute for additions of nitrogen as plant food for better crop yields.

Alfalfa is generally a beneficial soil-building legume. Legumes seeded with bermudagrass are grown for tame pasture and, under good management, produce favorable yields of forage. Tame pasture plants and native grasses are excellent soil conditioners and are appropriate parts of a long-term cropping system.

Wheat, mainly winter wheat, is the most extensive crop in Kay County. It is usually seeded between September 15 and October 15. In some years a considerable acreage of wheat is used for winter pasture. Barley is also used for winter pasture. Sorghum is grown mostly on the soils of the uplands. All of the forage sorghum is used on farms and ranches in the county, mostly as silage. Alfalfa, generally planted late in August, is grown in large areas along stream bottoms, and in years of favorable moisture, in the uplands. Oats are also grown in this county, mainly as feed for livestock. Oats are generally planted in spring following grain sorghum.

Capability Groups of Soils

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on limitations of the soils, the risk of damage when they are used, and the way they respond to treatment. The soils are classified according to degree and kind of permanent limitation, but without consideration of major and generally expensive landforming that would change the slopes, depth, or other characteristics of the soils; and without consideration of possible major reclamation projects.

In the capability system, all kinds of soils are grouped at three levels, the capability class, subclass, and unit. These are discussed in the following paragraphs.

Capability Classes, the broadest grouping, are designated by Roman numerals I through VIII. As the numerals increase, they indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I. Soils have few limitations that restrict their use.

Class II. Soils have some limitations that reduce the choice of plants or require moderate conservation practices.

Class III. Soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV. Soils have very severe limitations that restrict the choice of plants, require very careful management, or both.

Class V. Soils subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.

Class VI. Soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.

Class VII. Soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.

Class VIII. Soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes.

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only subclasses indicated by *w*, *s*, and *c*, because the soils in it are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-1, or IIe-2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation, and the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph.

Management by capability units

In the following pages, the capability units in Kay County are described and suggestions for the use and

management of the soils are given. To find the names of the soils in any given unit, refer to the "Guide to Mapping Units" at the back of this soil survey.

CAPABILITY UNIT I–1

This capability unit consists of deep, silty or loamy soils that are on nearly level bottom lands above the normal level of overflow. These soils occur along the rivers and other large streams of the county.

The soils in this unit are fertile, productive, and drought resistant. They are well drained or moderately well drained and have high water-holding capacity. Plant roots penetrate to a depth of several feet, but tillage is moderately difficult on Brewer silty clay loam and McLain silty clay loam.

The soils of this capability unit are among the best for farming in the county. Yields of all crops suited to this area are favorable. Small grains, principally wheat, and alfalfa are grown extensively. More alfalfa is produced as a cash crop on the soils of this unit than is produced on the soils of any other unit in the county (fig. 15). Soil tilth can be maintained by growing wheat or another high residue crop continuously and returning all the straw and other residue to the soil. Silage crops or other crops that leave little residue should be grown for not more than 6 consecutive years and followed by at least 2 years of a high residue crop. Alfalfa is a good cash crop on these soils, and many farmers have had excellent results from a rotation of wheat and alfalfa. If Austrian winter peas or some other crop for winter cover follows the silage crop or some other low residue crop, the water intake increases and the content of organic matter is maintained.

Figure 15.—Baled alfalfa hay on Reinach and Brewer soils.

CAPABILITY UNIT I–2

In this capability unit are deep, well-drained, level and nearly level soils on uplands. These soils have a loam or silt loam surface layer and a clay loam or silty clay loam subsoil.

The soils of this unit are fertile, friable, and easily worked. They absorb and store water well and release it readily to plants. To keep these soils productive, practices are needed that maintain fertility and soil structure. On some long slopes, erosion is a slight hazard.

These soils are suited to almost all crops commonly grown in the area. Small grains, mostly wheat, sorghum, and alfalfa are the main crops. Favorable yields of wheat or some other close-growing crop that provides a large amount of residue can be obtained continuously if the straw or other residue is mixed into the soil. Returning crop residue to these soils increases the intake of moisture, reduces surface crusting, and adds organic material. If a small grain is alternated with a legume, yields are favorable and fertility and tilth are easily maintained. Many farmers have excellent results when they use a rotation consisting of wheat and alfalfa, Austrian winter peas, or sweetclover. A winter cover crop is needed after silage crops are cut or after the harvesting of other crops that leave little residue. Tilling to a different depth each year helps to prevent the formation of a plowpan.

CAPABILITY UNIT IIe–1

This unit consists of deep, well-drained, very gently sloping soils on uplands. These soils are friable; they have a loam, silt loam, or silty clay loam surface layer and a clay loam to clay subsoil.

Generally, these soils are easy to till, but the Summit soil in this unit is moderately difficult to till. Because the water-holding capacity is good, crops on these soils withstand dry periods better than those on many other soils, especially those that have a claypan. If the soils of this unit are to be kept productive, practices are needed that control water erosion and that maintain soil structure and fertility.

The important crops grown on these soils are small grains, sorghum, and alfalfa. Winter wheat is the main crop. Yields of small grains or other close-growing crops are favorable for 6 consecutive years, but after this period, 2 years of alfalfa or sweetclover are needed. These legumes and their residues help to maintain the content of organic matter, to improve soil structure, and to increase the intake of water. Use of terraces is optional if this cropping system is followed; or if a small grain is grown continuously and fields are stubble mulched. Stubble mulching increases infiltration of moisture and helps to control erosion. If row crops are grown, contour tillage and terraces are needed to reduce erosion. A winter cover crop is needed after a silage crop or some other crop that leaves little residue. Crops grown on these soils respond well to additions of commercial fertilizer. Lime is generally needed where legumes are grown. Tilling at a different depth each year helps to reduce the formation of a plowpan.

CAPABILITY UNIT IIe–2

Shellabarger fine sandy loam, 1 to 3 percent slopes, is the only soil in this capability unit. This soil occurs on uplands and is deep and well drained. Its very dark grayish-brown to dark-brown surface layer grades to a brown or reddish-brown sandy clay loam subsoil at a depth of about 16 inches.

This soil is moderately high in natural fertility. It has moderate permeability and good water-holding capacity. Wind erosion, including winnowing, is likely in

areas that are not protected by a cover crop or plant residue. Practices are needed that control wind and water erosion, maintain soil fertility, and prevent crusting.

This soil is suited to all crops grown in the county. Small grains, sorghum, and legumes are commonly grown. Favorable yields of winter wheat or other close-growing crops can be produced for 6 consecutive years if crop residue is used effectively after each crop is harvested. Before wheat is grown for another long period, 2 years of a soil-building crop are needed. If stubble mulching is used and enough nitrogen is added, small grains or other high residue crops produce favorable yields year after year. Row crops can be grown on the contour or on terraces for 6 consecutive years if the row crops are followed by not less than 2 years of high residue crops. A winter cover crop is needed after cutting a silage crop, or after the harvesting of other crops that leave little residue on the soil.

Stubble mulching is a good practice for controlling wind and water erosion, increasing moisture infiltration, and improving tilth. Varying the depth of tillage helps to prevent the formation of a plowpan. Crops respond readily to additions of fertilizer, and these soils are benefited by the use of inoculated legumes.

CAPABILITY UNIT IIs-1

Only Tabler silt loam, 0 to 1 percent slopes, is in this unit. It is a deep soil of the uplands. Its dark-gray, slightly acid silt loam surface layer is underlain by a dense, very slowly permeable clay subsoil at a depth of 8 inches.

The clay subsoil absorbs water very slowly and restricts the growth of roots. The amount of water available to plants is limited. Runoff is slow, and water commonly ponds after heavy rains. Management is needed that maintains structure and fertility, that increases the intake of water, and that provides adequate surface drainage in the depressions. Erosion is likely only in areas adjacent to drainageways or very gentle slopes.

Crops suitable for this soil are small grains, other close-growing crops, and sorghum. Not enough moisture is available for corn or other crops that use a large amount of moisture in summer. The yields of small grains are more dependable than those of sorghum because the grain matures before dry weather comes in summer. All residue from the small grains should be returned to the soil. Other close-growing crops can be seeded year after year, and they produce favorable yields if good use is made of crop residue. If sweetclover, alfalfa, and other deep-rooted legumes are grown, the intake of water is increased and soil structure is improved. Row crops can be grown for as long as 6 consecutive years if they are followed by at least 2 years of legumes. The legumes help to maintain fertility and tilth. Tillage that leaves part of the straw on the surface reduces crusting and checks wind erosion. In the small depressions, productivity can be increased by using simple drainage practices.

CAPABILITY UNIT IIs-2

Only one soil—Waurika silt loam—is in this capability unit. This deep soil is in level to depressional areas of the uplands. Its gray silt loam surface layer is underlain by a clay subsoil that takes in water very slowly.

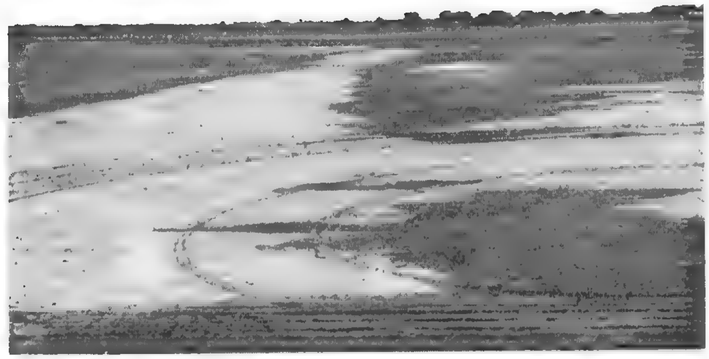

***Figure 16.*—Surface water ponded on Waurika silt loam several days after rain.**

The clay subsoil restricts the growth of roots and limits the amount of water available to plants. Tillage is moderately difficult. The content of organic matter is medium to low and drought is likely in summer. After heavy rains, however, water ponds on the surface (fig. 16). In cultivated areas, adequate drainage is needed, especially in years when rainfall is average or above.

Crops suitable for this soil are small grains, sorghum, and legumes. Yields of small grains are favorable, and yields of sorghum and legumes are fairly favorable. Surface crusting can be reduced by growing a high residue crop half of the time and making good use of the crop residue. Sweetclover or Austrian winter peas improve soil structure and, by loosening the subsoil, improve internal drainage. Crops that produce only a small amount of residue should not be grown for more than 4 consecutive years.

Open ditches or tile drains are suitable in most areas for removing ponded surface water. To reduce crusting and to check wind erosion, all residue from small grains should be returned to the soil. Varying the depth of tillage helps to prevent the formation of a plowpan.

CAPABILITY UNIT IIw-1

Only Carwile-Pratt complex, undulating, is in this capability unit. This complex is on uplands and consists of soils that have a surface layer generally ranging from fine sandy loam to loamy fine sand.

The Carwile soils are in depressions and have a very slowly permeable, mottled clay subsoil. They are somewhat poorly drained. The Pratt soils are very gently sloping and have a rapidly permeable loamy fine sand subsoil. On the soils in this complex, practices are needed to improve drainage, control wind erosion, and maintain fertility.

Crops suitable for these soils are small grains, sorghum, and legumes. A good cropping system consists of small grains grown for 6 years and followed by 2 years of sweetclover or alfalfa. It is not advisable to grow row crops for more than 4 consecutive years. After each row crop is harvested, a winter cover crop should be seeded to protect these soils from blowing late in winter and early in spring.

Draining the depressions helps to insure crop production in years of average or above average rainfall. Tillage that roughens the surface and stubble mulching are effective in controlling wind erosion. Plowing under legumes and returning all crop residue to the soils help to maintain the content of organic matter and to increase the intake of moisture. Crops grown in these soils respond to additions of fertilizer. Varying the depth of tillage helps to prevent formation of a plowpan.

CAPABILITY UNIT IIw-2

This capability unit consists of deep, well-drained, loamy soils on nearly level bottom lands that are occasionally flooded. These soils are adjacent to the rivers and other streams throughout the county.

The soils of this unit are fertile and highly productive. They are well drained and have a high water-holding capacity. Tillage is easy. Use of these soils is limited mainly by flooding after heavy rains, but the floods normally only slightly damage crops.

Although floods are occasionally damaging, these soils are among the best for farming in the county. They are suited to most crops grown in the area. Small grains, principally wheat, and alfalfa are grown extensively. Alfalfa is especially well adapted since it is only slightly damaged by the occasional flooding. Also well suited are improved varieties of bermudagrass, and they grow well in the areas flooded more often.

Tilth is maintained if small grains or other high residue crops are grown continually and all crop residue is returned to the soil. Silage crops or other crops that produce little residue should be grown for not more than 6 consecutive years and followed by at least 2 years of high residue crops. After a low residue crop is harvested a crop of Austrian winter peas helps to increase water intake and maintain the content of organic matter. Many farmers have successfully practiced a rotation consisting of alfalfa and wheat. Varying the depth of tillage each year reduces the formation of a plowpan.

CAPABILITY UNIT IIw-3

This unit consists of deep, nearly level to very gently undulating, moderately coarse textured soils on bottom lands along rivers that often overflow. These soils have a surface layer of fine sandy loam that extends to a layer of fine sandy loam stratified with loamy sand to silty clay.

The soils in this unit are moderately fertile, drought resistant, and moderately productive. They are rapidly permeable and have moderate water-holding capacity. Tillage is easy, but floods commonly destroy crops and damage the cropland. Soil material is deposited in some places by the floods and is removed in others. Occasionally, the large floods gouge out potholes. If these soils are to be kept productive, practices are needed that maintain fertility and soil structure and that control erosion.

These soils are suited to almost all crops commonly grown in the area. Wheat and sorghum are the main crops. Some of the areas that are flooded most often have been planted to bermudagrass and provide excellent grazing. Favorable yields of field crops can be expected year after year if crop residue is returned to the soil. Row crops or other crops that provide little residue can be grown for as many as 6 consecutive years if they are followed by at least 2 years of crops producing large amounts of residue. After each row crop or low residue crop is harvested, a close-growing crop should be seeded to protect these soils from blowing in winter and early in spring. Stubble mulching and keeping crop residue on the surface are also effective in controlling wind erosion. Crops grown on these soils respond readily to the use of legumes in the cropping system and to additions of commercial fertilizer.

CAPABILITY UNIT IIIe-1

Kirkland silt loam, 1 to 3 percent slopes, is the only soil in this capability unit. This is a deep, very gently sloping soil on uplands. It has a loamy, dark grayish-brown surface layer about 10 inches thick. The subsoil is dark-brown clay that takes in water very slowly and is very slowly permeable.

This soil has moderately high natural fertility, but it tends to be droughty, especially where water erosion has removed some of the surface layer. Management is needed that maintains the structure and fertility of the soil, conserves moisture, and reduces runoff.

This is the main wheat-producing soil in the county, but other small grains, sorghum, and alfalfa are also grown. Crop yields are favorable. Results have been good where wheat or another high residue producing crop has been grown continuously and good use has been made of the residue. Many farmers use a cropping sequence of small grain followed by alfalfa, sweetclover, or Austrian winter peas. This sequence increases the intake of water and helps maintain the fertility and structure of the soil. Where contour tillage and terraces are used, row crops can be grown for 4 consecutive years if they are followed by 2 years of legumes. By plowing under alfalfa or other legumes when they reach a height of 12 inches or more, soil aeration, intake of water, and the content of organic matter are increased.

Practices are needed that reduce erosion by holding on the surface much of the rain that falls so that it can soak into the soil. Among these practices are terracing, seeding legumes, using crop residue (fig. 17), and tilling at a

Figure 17.—Small grain straw evenly distributed on the surface of Kirkland silt loam, 1 to 3 percent slopes, provides good protection from erosion while the seedbed is prepared.

minimum. Lime is generally needed to establish legumes and to make more efficient use of commercial fertilizer. Varying the depth of tillage helps prevent the formation of a plowpan.

CAPABILITY UNIT IIIe–2

This capability unit consists of deep to moderately deep, gently sloping soils on uplands. These soils have a sandy loam to silty clay loam surface layer and a sandy clay loam to clay subsoil that stores moisture well.

The soils in this unit have moderately high natural fertility. Summit silty clay loam, 3 to 5 percent slopes, is moderately difficult to till, but the rest of the soils are easy to till. A few gravel spots of the Albion soil in Norge-Albion complex, 3 to 5 percent slopes, are droughty and low in fertility. In managing the soils of this unit, practices are needed that control water erosion and that maintain soil structure and fertility.

These soils are suited to all crops commonly grown in the county. Crop yields are favorable. Wheat is the main crop. The content of organic matter and soil tilth can be maintained if high residue crops are grown for 6 consecutive years and are followed by legumes for 2 years. The loss of soil is reduced if these soils are cultivated on the contour and tillage operations are timely and are kept to a minimum. Varying the depth of tillage prevents the formation of a plowpan. Soil-depleting crops can be grown for 4 consecutive years if they are followed by 4 years of high residue crops. Where row crops are grown, terraces and contour tillage are needed to slow runoff and control erosion. Tilth is better maintained and erosion is better controlled if a row crop does not follow a row crop in the cropping system. Applications of fertilizer are beneficial because they increase yields of most crops and the amount of residue that can be used to protect these soils.

CAPABILITY UNIT IIIe–3

This unit consists of moderately eroded, gently sloping soils on uplands. These soils are deep to moderately deep and have a loam or clay loam surface layer and a clay loam or silty clay loam subsoil.

The soils of this unit are low or medium in natural fertility and content of organic matter. They have rapid runoff and are moderately difficult to till. Water erosion is the main limitation. More careful management is needed than on the soils in capability unit IIIe–2. Practices are needed that maintain fertility, reduce surface crusting, and increase the intake of water.

Small grains, mainly winter wheat, are grown extensively. Crop yields are fair. Among the practices needed to control water erosion are terracing, contour farming, and maximum use of crop residue. Grassed waterways are needed with the terraces to prevent gullying and other erosion downslope. If a cropping system is used in which legumes are grown for one-fourth of the time, the subsoil is opened up and more water is absorbed. Growing row crops for more than 2 successive years is not advisable. Nitrogen is needed to aid in the decomposition of straw and other residue and to improve the vigor of nonlegumes. It may also be needed for establishing legumes.

CAPABILITY UNIT IIIe–4

Shellabarger fine sandy loam, 3 to 5 percent slopes, is the only soil in this capability unit. It is a deep, dark-brown soil of the uplands that has a friable surface layer and a moderately permeable sandy clay loam subsoil. This soil is susceptible to both wind and water erosion. It is easily tilled, but depth of tillage should be varied to prevent the formation of a plowpan. Although natural fertility is moderate, maintaining fertility is difficult, especially where erosion has thinned the surface layer slightly. Wind erosion is most likely in excessively tilled areas, in areas not stubble mulched, and in areas not protected by residue.

Small grains, sorghum, and legumes are suitable crops and produce favorable yields. If contour tillage and stubble mulching are used, a profitable cropping system is small grains grown for 6 successive years and followed by 2 years of legumes. Growing row crops for more than 3 consecutive years is not advisable. Where row crops are grown, terraces and contour tillage are needed to reduce water erosion and a winter cover crop is needed to reduce wind erosion. In spring, preparation of seedbeds should be delayed until near planting time. If moisture is adequate, crops respond well to additions of fertilizer. By using inoculated legume seeds, nitrogen is effectively added to these soils.

CAPABILITY UNIT IIIe–5

Only Dougherty-Eufaula complex, 0 to 3 percent slopes, is in this capability unit. The Dougherty soils have a grayish-brown fine sandy loam surface layer and a sandy clay loam subsoil. The Eufaula soils have a dark-colored surface layer and lighter colored lower horizons of deep fine sand. The soils in this unit are loose and very friable, and they have low content of organic matter and low natural fertility. They absorb much rain that falls, but not much of this moisture is available for crops. Moderate or severe wind erosion is likely, especially in winter and early in spring. During high winds, soil material blows and drifts in unprotected fields.

Suitable crops are small grains and sorghum. Vegetables and fruits can be grown successfully if fertility is kept high. If adequate fertilizer is added, bermudagrass or mixed vetch and rye can be grown for tame pasture. High residue crops should be included in the cropping system for not less than half of the time, and the fields should be stubble mulched and adequately fertilized. Plant nutrients are reduced if low residue crops are grown for more than 3 consecutive years. Following these crops, Austrian winter peas, vetch, or some other crop is needed for winter cover so that wind erosion is controlled. Also helpful in controlling wind erosion are tilling and planting crops crosswise to the prevailing winds. In spring, preparation of seedbeds should be delayed until the critical period of blowing has almost ended. Perennial vegetation is needed in drainageways.

CAPABILITY UNIT IIIs–1

Only one soil, Yahola loamy fine sand, is in this capability unit. It is a deep, coarse-textured alluvial soil on first bottoms of the Salt Fork Arkansas River that are occasionally to frequently flooded.

Use of this soil for farming is limited chiefly by low fertility, low water-holding capacity, and susceptibility to wind erosion. Because the water is absorbed readily, crop yields are not usually reduced by the occasional floods.

Small grains, sorghum, alfalfa, and sweetclover are suitable crops. If adequate fertilizer is added, bermudagrass is excellent for pasture. A desirable cropping system is one that provides high residue crops for at least half of the time, efficient use of the residue, and adequate additions of nitrogen fertilizer. Growing row crops for as much as 3 consecutive years is not advisable. To reduce wind erosion, a winter cover crop is needed after the harvesting of silage or other crops that leave little residue. Tilling crosswise to the direction of the prevailing wind helps to reduce soil blowing. Wind erosion is reduced directly by stubble mulching and indirectly by added fertilizer, which increases the protective cover and the amount of crop residue.

CAPABILITY UNIT IIIw-1

This unit consists of somewhat poorly drained soils in depressions on bottom lands that are flooded occasionally. These soils have a clay surface layer and subsoil that absorb water slowly.

Although these soils are fertile, they are hard to farm. Tillage is generally difficult, and farmers often have trouble establishing a good stand of crops. Crops are drowned in some years because of flooding and lack of surface drainage. In wet years these soils are commonly too wet to cultivate.

These soils are suited to small grains and sorghum, and alfalfa can be grown in drained areas. Small grains can be grown continuously if good use is made of the residue. Crops that produce only a small amount of residue can be grown for 2 successive years if they are followed for 6 years by high residue crops and the residue is returned to the soil. Sweetclover, alfalfa, and similar legumes improve soil structure, increase the intake of water, and improve aeration. Open ditches can be used to remove most of the excess surface water that remains after heavy rains. Where these soils are not drained, crops respond poorly to other management.

CAPABILITY UNIT IVe-1

Vernon clay loam, 3 to 5 percent slopes, is the only soil in this capability unit. It is a shallow soil on uplands. Its reddish-brown surface layer is underlain by a clay subsoil. Beds of unweathered calcareous clay and shale are at a depth of 10 to 20 inches.

This soil is difficult to till. It has low water-holding capacity and is droughty. Runoff is excessive, permeability is very slow, and the hazard of water erosion is moderate.

This soil is not well suited to cultivation, though small grains, sorghum, and legumes are grown. Wheat is the main crop. Crop yields are low to fairly favorable, depending on the amount of rainfall. In stubble-mulched fields, a good cropping sequence that increases water intake is 3 years of high residue crops and 3 years of legumes. Terraces and contour farming are needed for a cropping system that consists of 6 consecutive years or more of high residue crops followed by 2 years of row crops. For even fair yields, careful management is required. A special effort should be made to hold much of the rain where it falls so that erosion is controlled and more water soaks into the soil and is available for crops.

CAPABILITY UNIT IVe-2

Only Kirkland-Renfrow complex, 2 to 5 percent slopes, eroded, is in this capability unit. These soils are on uplands and have a brownish silt loam or clay loam surface layer and a clay or claypan subsoil that is very slowly permeable.

The soils in this unit are moderately difficult to till. Surface runoff is rapid. The clay subsoil holds little moisture available for crops. If these soils are to remain in cultivation, practices are needed to control runoff and erosion and to maintain soil structure and fertility.

Crops suitable for these soils are small grains, sorghum, and legumes. Yields are low. If crop residue is used effectively, a suitable cropping system is 6 consecutive years of high residue crops followed by 2 years of low residue crops. Row crops are not desirable, because they increase the hazard of erosion. Terracing and contour farming are practices that reduce erosion and increase the water available for crops by holding much of it where it falls. Grassed waterways are also needed where practical. Returning crop residue to the soil adds organic matter and reduces surface crusting. The roots of sweetclover, Austrian winter peas, and alfalfa open up the clay subsoil and also add nitrogen to the soil if the seeds have been inoculated. Minimum tillage soon after harvest increases infiltration, controls the growth of weeds, and speeds up the decay of crop residue. Varying the depth of tillage each year helps prevent the formation of a plowpan and helps to maintain soil structure.

CAPABILITY UNIT IVe-3

This unit consists of deep, well-drained, sloping soils of the uplands. These soils have a loam, silt loam, or clay loam surface layer and a moderately fine textured subsoil that absorbs water well and holds a large amount available for plants.

Natural fertility and content of organic matter are moderate in these soils. Labette clay loam, 5 to 8 percent slopes, is more difficult to till than the other soils in this unit. Much water is lost in runoff. Practices are needed to reduce water erosion and to maintain soil structure.

These soils are suited to small grains, sorghum, and legumes. About 90 percent of Labette clay loam, 5 to 8 percent slopes, is in native grassland. A cropping system that conserves soil and moisture consists of small grains and legumes, each grown for half of the time. If additional pasture is needed, sweetclover, alfalfa, and Austrian winter peas are suitable legumes. Also suitable is a mixture of vetch and rye. Terraces are not required for pasture if contour stripcropping is practiced. Crops that deplete the soil should not be grown in successive years. Where cultivated crops are grown, terraces, contour tillage, and, where applicable, grassed waterways are required. Stubble mulching or effective use of crop residue increases infiltration and reduces runoff. In some areas diversion terraces are needed to protect Labette clay loam, 5 to 8 percent slopes, from water that runs in from higher, steeper slopes. Crops on the soils of this unit respond readily to fertilizer.

CAPABILITY UNIT IVe-4

Norge loam, 5 to 8 percent slopes, eroded, is the only soil in this capability unit. This deep, loamy soil occurs on uplands, mainly on short side slopes along intermit-

tent drainageways or draws. The subsoil is clay loam. From 30 to 70 percent of the original surface layer has been removed through sheet and rill erosion.

Controlling water erosion is most important if farming is to be economical. Runoff is rapid.

Small grains and legumes are suitable crops. Wheat is the principal crop. In many areas bermudagrass is better suited than small grains or legumes because it controls erosion better and, where well managed, provides a higher return. Small grains produce satisfactory yields and do not deplete the soil if terraces and contour tillage are used and crop residue is returned to the soil. In some places waterways and diversion terraces are needed for disposing of excess water. Growing legumes, stubble mulching, and using crop residue help to maintain soil tilth and fertility and to increase the water intake. Varying the depth of tillage each year helps to reduce the formation of a plowpan.

CAPABILITY UNIT IVe–5

Only one soil—Shellabarger fine sandy loam, 5 to 8 percent slopes—is in this capability unit. It is a deep soil of the uplands that has a moderately permeable sandy clay loam subsoil.

This loamy soil is moderately fertile. It is friable and easily tilled. Wind erosion is a hazard and is more severe where tillage is excessive or where ground cover is lacking. If this soil is farmed, practices are needed to protect it from water and wind erosion, to control runoff, and to increase the content of organic matter.

This soil is used for wheat and other small grains, but it is also suitable for sorghum and legumes. More than half of it is rangeland. The native grasses are mostly bluestem. A suitable cropping system is one that provides small grains or other close-growing field crops half of the time and legumes the other half. Where this cropping system is used, terraces are optional but stripcropping is necessary. High residue crops can be grown for 3 consecutive years and followed by a low residue crop for 1 year if terraces and contour farming are used, crop residue is returned to the soil, and adequate nitrogen fertilizer is added.

The hazard of wind erosion is reduced if a winter cover crop follows a low residue crop. Row crops do little to control erosion and should not be grown on this soil. Growing legumes and stubble mulching or using all crop residue help to maintain soil structure and fertility and to increase the intake of water. In spring preparation of seedbeds should be delayed until the critical period of blowing has ended. Varying the depth of tillage each year helps to prevent the formation of a plowpan.

CAPABILITY UNIT IVe–6

The soils in this capability unit occur on uplands and are deep and grayish brown. They have a fine sand, loamy fine sand, or fine sandy loam surface layer and a fine sand to sandy clay loam subsoil.

These soils are susceptible to moderate or severe wind erosion, especially in spring. Their intake of water is moderate to moderately rapid, and their water-holding capacity is low. They are friable and easily tilled. Natural fertility is low.

Small grains, legumes, truck crops, and some fruits are suitable for these soils. Crops respond well to additions of fertilizer if other management is good and if the supply of moisture is average or above average. If stubble mulching is practiced and adequate nitrogen fertilizer is applied, high residue crops grown continuously protect these soils and produce satisfactory yields. Perennial vegetation should be established in drainageways. A mixture of vetch and rye provides excellent ground cover in winter and early in spring, as well as abundant desirable forage for grazing.

Wind erosion can be controlled by stubble mulching and by keeping a cover of growing plants on the ground. Because fertilizer is easily leached from these soils, crops benefit most if it is applied in small amounts several times during the growing season. To minimize the hazard of wind erosion seedbeds should be prepared late in spring. Varying the depth of tillage each year helps to prevent the formation of a plowpan.

CAPABILITY UNIT IVe–7

Only Renfrow-Kirkland silt loams, 3 to 5 percent slopes, is in this capability unit. These deep soils of the uplands have a dense, compact clay subsoil.

The compact subsoil absorbs water very slowly. Runoff is rapid. Erosion has thinned the surface layer in cultivated areas that have been poorly managed. Natural fertility and the content of organic matter are moderate. Good management of these soils includes maintaining soil structure and fertility, controlling runoff, and conserving moisture.

Suitable crops are small grains, sorghum, and legumes. Most of the acreage of these soils is in native pasture. Short grasses are dominant in the pastures because grazing has been excessive. In cultivated areas careful management is required to control water erosion. Stubble mulching and contour tillage are effective in reducing erosion and in increasing the intake of water. Good yields of small grains can be expected if legumes are grown half of the time. Inoculated legumes add nitrogen to the soil and open up the clay subsoil so that more moisture is stored for plants. Low residue crops can be grown for 2 successive years if they are followed by 6 years of high residue crops. Where these crops are grown, terraces and contour tillage are helpful in controlling erosion. All crop residues should be returned to the soil to provide organic material.

CAPABILITY UNIT IVe–8

Reinach loam, 3 to 8 percent slopes, is the only soil in this capability unit. This is a deep soil on bottom lands. It occupies sloping breaks, 100 to 200 feet wide, that separate low bottom lands from higher bottom lands.

This soil is easily tilled, but in many places the narrow slopes are not well suited to use of modern farm equipment. In managing this soil, concerns are controlling water erosion and maintaining tilth and fertility.

Most areas of this soil are farmed with the less sloping Reinach loams. The main crops are small grains and alfalfa. Tame pastures of bermudagrass are well suited to this sloping soil. Yields from a rotation of small grains and alfalfa are favorable. Stubble mulching the residue from these crops protects the surface and reduces erosion. If constructing a diversion terrace above the sloping areas is feasible, the terrace helps control erosion. It is not advisable to grow row crops on this soil. Applications of nitrogen increase yields of most crops and the amount of

vegetation that can be returned to the soil and used for stubble mulching. Varying the depth of tillage each year helps to prevent the formation of a plowpan and to increase the intake of water.

CAPABILITY UNIT IVs-1

Only the Lela-Slickspots complex is in this capability unit. This complex is on bottom lands and consists of somewhat poorly drained, dark-colored, clayey soils that are moderately saline and alkaline.

Salinity and alkalinity are not uniform throughout this mapping unit, of which light-colored alkali spots, or slickspots, make up 10 to 30 percent. In cultivated fields slickspots have a puddled surface layer. Erosion is not a serious limitation, but drainage and maintenance of soil structure are required if these soils are cultivated. Surface crusting is common, and the intake of water is very slow. The soils are generally difficult to till, and a good stand of crops is hard to establish.

Most of this mapping unit is cultivated, but many areas are in native grass. Suitable crops are small grains, sorghum, and sweetclover. Yields are low because the areas are saline and alkaline. Adequate drainage is essential in improving these areas. A cropping sequence of barley and sweetclover helps to improve tilth and fertility. The sweetclover opens up the dense clay subsoil and allows some downward movement of harmful salts. Also, returning as much crop residue as possible to the soils helps to reduce surface crusting and to increase the intake of water. The structure of slickspots can be improved by adding 3 to 4 tons of straw, old hay, or other organic material per acre and, for each ton, 20 pounds of nitrogen. In addition to the mulch, gypsum added at the rate of 3 to 5 tons per acre is helpful. Slickspots that have been mulched should be deferred from tillage for a minimum of two growing seasons.

CAPABILITY UNIT IVs-2

Only Labette-Slickspots complex, 3 to 5 percent slopes, eroded, is in this capability unit. The soils of this complex are on uplands. Labette, the dominant soil, has a clay loam surface layer that is about 3 to 7 inches thick over a clay or clay loam subsoil. The slickspots have a thin, light-colored surface layer over a clay subsoil. They are around the heads of drainageways where water concentrates. Erosion ranges from moderate to severe. In about 60 to 80 percent of the acreage, mixing of the surface layer and subsoil is evident. Small slickspots, or areas moderately affected by white alkali, make up about 20 percent of this complex.

The soils in this unit have rapid runoff and are highly susceptible to severe water erosion. They are droughty and have low natural fertility. Managing these soils include improving soil structure, reducing surface crusting, reducing salinity, and controlling accelerated water erosion on the slickspots.

Suitable crops are small grains and sweetclover. Crop yields are low. These soils are well suited to permanent vegetation. Careful management is needed if these soils are to remain in cultivation. A cropping system that includes small grains and sweetclover, each grown for the same length of time, provides satisfactory yields if stubble mulching is practiced and adequate nitrogen fertilizer is added. To help prevent the slickspots from increasing in size, they should not be tilled deeper than 4 inches. Perennial vegetation is needed in natural drainageways. Added fertilizer increases yields. It also increases plant growth so that ample residue is available for stubble mulching. The slickspots can be mulched with 3 to 4 tons of straw, hay, or other organic material per acre and for each ton, 20 pounds of nitrogen. In addition to the mulch, gypsum applied at a rate of 3 to 5 tons per acre helps to reduce salinity. For best results, tillage operations are deferred on treated areas for two growing seasons.

CAPABILITY UNIT Vw-1

Only Broken alluvial land is in this capability unit. This land type consists of broken and steep areas that occur in a belt along streams. The soil material is deep, dark colored, and predominantly loamy.

This land type is fertile, but it is of limited value for farming because it is inaccessible and frequently flooded. The native vegetation consists of bottom-land trees and shade-tolerant shrubs, weeds, and grasses. Areas of this land that adjoin larger areas of grass or wheat pasture can be used for grazing and can be improved by good management. The more uniform areas are improved by seeding them to bermudagrass, which grows well and is not easily damaged by flooding. The more clayey areas are suitable for pecan trees.

This land type is excellent for wildlife and for recreation. Fishing is good in the larger streams. Good food, cover, and water are available for quail, deer, mink, muskrat, squirrels, and other wildlife. Squirrels are numerous along all streams.

CAPABILITY UNIT Vw-2

This capability unit consists of nearly level to very gently sloping soils on low bottom lands next to rivers. These soils are frequently flooded.

The Lincoln soils in this unit are stratified sands that are low in fertility. They formed in alluvium that has been reworked by flooding and shifting of the river channels and by action of wind. The water table is generally high, but it fluctuates according to the amount of precipitation. Port soils, frequently flooded, are loamy and high in fertility. They occur mostly along the Chikaskia River.

The soils of this unit are not well suited to cultivation. Most areas of Lincoln soils are covered with a mixture of johnsongrass, sand bluestem, switchgrass, Canada wildrye, and scattered tall trees. Much of the acreage of Port soils, frequently flooded, is densely covered with trees. Port soils can produce high yields of almost all crops commonly grown in the county, but damaging floods are frequent and prevent economical production of crops. Bermudagrass grows well on the soils of this unit, and reduces scouring and the gouging of potholes during floods. Pecan trees grow well in some areas.

These soils are good habitat for wildlife. They provide excellent cover and food for quail, rabbits, wild turkeys, and squirrels.

CAPABILITY UNIT VIe-1

Only Eroded clayey land is in this capability unit. This land type is in small areas surrounded by Kirkland, Renfrow, Vernon, Labette, Summit and other soils of the

uplands. Surface runoff is rapid, and water intake is very slow. If this land is to be of any value for farming, practices are needed to control water erosion and to improve soil structure and fertility. This land type is in the uplands in severely eroded and gullied areas that are not suitable for cultivation. The soil material is clayey.

Long periods of cultivation and mismanagement have led to severe water erosion. In most areas the vegetation is silver bluestem and perennial three-awn. Generally, the stand of grasses are thin or lacking near gullies but are moderately good between the gullies. It is advisable to seed desirable native grasses and to manage for the purpose of maintaining good stands. Once the stand is established, control of grazing is required so that a mulch will remain to protect the surface from further erosion. If water is diverted above the severely eroded areas, rills and gullies generally tend to stabilize.

CAPABILITY UNIT VIe-2

Only Eroded loamy land is in this capability unit. All or much of the surface layer of this land has been removed by water erosion, and areas have been scarred by deep gullies. This land is generally sloping around the heads of drainageways.

At one time almost all of this land was cultivated. Severe erosion and the network of gullies now make it unsuited for cultivation. At great cost, some areas could be reclaimed and used for crops or for bermudagrass pasture. Because the texture of the subsoil and substratum is loamy and raw clays and rocks are not present, power equipment can be used to fill the gullies. In the present surface layer, the content of organic matter can be built up by using intensive management. Because improving this land is costly, however, most farmers prefer to keep the small areas in pasture. If intensive methods are not used to reclaim this land, less intensive practices are needed before this land can be used for pasture. Practices are needed to control erosion, increase water intake, and improve soil structure.

A practical method of stabilizing the gullies is to build terraces that divert water from higher lying uplands. After the water is diverted, the gullies gradually fill and grass grows. By seeding desirable native grasses a stand can be obtained quickly. Bermudagrass has been grown successfully in some gullies. It is quickly established, and when established, it reduces erosion and provides some grazing. Control of grazing is necessary so that cover is sufficient to protect this land from further erosion.

CAPABILITY UNIT VIe-3

Only Loamy broken land is in this capability unit. This land type is in sloping to steep, broken areas of deep, loamy soil material. It is mainly in narrow bands that separate bottom lands from uplands.

In most areas this land is well stabilized, but it is susceptible to severe water erosion because the slopes are steep. The soil material is loamy and has good water-holding capacity.

Use of this land is limited to range. The native vegetation is principally trees and brush, but there are scattered tall grasses and native legumes. Some of the less sloping areas can be cleared and planted to bermudagrass pasture. To prevent erosion, good range management that includes control of grazing is needed.

This land is excellent habitat for wildlife. Cover is excellent for quail, squirrel, and several other kinds of wildlife.

CAPABILITY UNIT VIe-4

Only Breaks-Alluvial land complex is in this capability unit. This land type is made up of small natural drainageways and their side slopes. It occurs in prairie uplands. The drainageways are long and narrow, and they drain into local streams. Flash floods are common. The texture of the soil material is loamy on the bottoms of the drainageways and is clayey to loamy on the side slopes. Shallow soils and banding escarpments make up the side slopes in some areas.

On this land type, management is required that controls the rapid runoff and increases the low intake and storage of water.

Nearly all of this land is in native pasture. The vegetation consists of little bluestem, sideoats grama, buffalograss, blue grama, and other native grasses, and there are scattered elm and cottonwood trees on the small alluvial bottoms. A few small areas are cultivated. If the steep side slopes are cultivated, severe water erosion is likely. Range management, including control of grazing, is needed to reduce erosion and to maintain the vigor of desirable grasses.

This land is an excellent habitat for quail and rabbits.

CAPABILITY UNIT VIe-5

This capability unit consists of shallow, gently sloping to strongly sloping soils underlain by beds of clay and shale. These soils occur in the central and western parts of the county on rough broken escarpments and in drainageways. A few outcrops of shale or clay, free of vegetation, occur around the rims of the escarpments.

Strong, broken slopes, exposed beds of clay and shale, and susceptibility to erosion make the soils in this unit unsuited to cultivation. Surface runoff is rapid. Water-holding capacity is low, and these soils are droughty.

Vegetation consists mainly of sideoats grama, little bluestem, and buffalograss. A few scattered pricklypears grow in very shallow areas. Range management, including control of grazing, is needed to prevent erosion.

CAPABILITY UNIT VIs-1

Only Sand dunes, Lincoln material, is in this capability unit. This land type consists of choppy sand dunes on the flood plains of the Arkansas and Salt Fork Arkansas Rivers.

These dunes are highly susceptible to wind erosion. Although they readily absorb water, they hold little of it and are droughty. Fertility is low.

Use of this land is limited chiefly to range. Most areas are stabilized by plum thickets, sand bluestem, little bluestem, sand lovegrass, and some scattered trees. Range management is needed that encourages the growth of plants in a protective cover to control wind erosion.

CAPABILITY UNIT VIIs-1

This capability unit consists of moderately deep Summit soils and very shallow Sogn soils on limestone escarpments in the eastern part of the county. The Sogn soils are mapped as an undifferentiated unit and also as a complex with Summit soils.

In this capability unit Sogn soils, 1 to 3 percent slopes, are very shallow, droughty, and on uplands and the Sogn-Summit complex, 5 to 20 percent slopes, is on limestone escarpments and rocky colluvial foot slopes. The deeper areas of Summit soils are fertile and hold moisture well.

The soils of this capability unit are not suitable for cultivation. The deeper soils are in areas too small to cultivate separately, and these areas are interspersed among areas of very shallow soils. The soils in this unit are used for range. The very shallow Sogn soils produce only a small amount of forage, but the deeper Summit soils have more moisture available for plants and are highly productive of native grasses. The native vegetation consists of big bluestem, little bluestem, indiangrass, and switchgrass, and there are a few scattered shrubs along the limestone ledges. Range management that includes control of grazing and protection from fire is needed to reduce erosion and to keep pastures productive.

CAPABILITY UNIT VIIIs-1

Only Oil-waste land is in this capability unit. The land type occurs in the oilfields of the county, mainly south of Tonkowa, northeast of Braman, and northeast of Washunga. The areas are generally small, but a few are larger than 20 acres.

This land has been used as a disposal field for waste oil and salt water from oil wells and drilling operations. In many areas small patches are not strongly affected by waste oil or salt water, but the land as a whole is so affected that it is bare or nearly bare. In its present condition, this land has no value as cropland or grassland. Some of the less sloping and less severely gullied areas may revegetate naturally if no more waste is dumped on them.

Predicted Yields [3]

Table 2 shows predicted long-term, average yields for wheat, barley, and grain sorghum, the main crops grown in Kay County, and for forage sorghum, alfalfa, and bermudagrass. Yields are shown for two levels of management and are predicted only for arable soils. Soils not generally used for crops or pasture are not listed in table 2. The predictions are averages for a period long enough to include both dry and wet years. Yields are considerably higher than those averages in years when the supply of moisture is favorable and are lower in years when the moisture supply is unfavorable.

The predictions are based partly on records of fertility studies, crop variety tests, and rotation and tillage trials made by the Oklahoma Agricultural Experiment Station and partly on information obtained during the course of the soil survey by observation and by personal communication with farmers.

The yields shown in columns A are those that can be expected under common management, or management practiced by a substantial number of farmers in the county. Common management normally includes (1) proper seeding rates, proper dates of planting, and efficient harvesting methods; (2) sufficient control of weeds, insects, and plant diseases to insure good growth of plants; (3) use of terraces and contour farming where needed; (4) small applications of lime and fertilizer to cash crops; and (5) early plowing where practical.

The yields in columns B can be expected under improved management. Improved management includes the first three practices listed under common management plus (1) applications of the kinds and amounts of fertilizer and lime indicated by soil tests; (2) management of crop residue and methods of tillage that control erosion, maintain desirable structure, increase the infiltration of water, and enhance the emergence of seedlings; (3) surface drainage where needed; (4) use of adapted and improved varieties of crops and pasture plants; (5) use of cover crops or stripcropping on sandy soils that tend to blow; and (6) good management of livestock grazing winter small grains.

If the yields for tame pasture listed in table 2 are to be obtained, special attention must be given to the distribution of salt and water for uniform grazing and to the use of fences for deferred or rotation grazing. Also, the control of brush and weeds is needed.

Management of Range [4]

In Kay County much of the income from farms and ranches is from the sale of livestock and livestock products. On most of the farms and ranches cattle are the main livestock; only a few sheep are raised. The number of cattle, including calves, in the county usually ranges from 45,000 to 50,000.

Most production of livestock is from native rangeland, though some crops and their byproducts are used for feed. About one-third of the farmland in the county is range, most of it in the eastern part. This eastern area is the southern limit of the Flint Hills Prairie, which extends across Kansas to the Nebraska line.

In addition to producing pasture and hay for livestock, native rangeland supplies food and cover for wildlife. Also, well-managed rangeland contributes to flood control because much of the precipitation that falls soaks into the ground and does not swell the stream.

Range sites and condition classes

A range site consists of soils that support similar vegetation and are similar in depth, texture, permeability, and topography. The sites differ significantly in the kinds of natural vegetation they now support; in the kinds of original, or climax, vegetation they once supported; and in the kind of management they need. Knowing the potential of the various range sites is a part of good range management. Generally a range site made up of deep soils that hold moisture well is a favorable place for growing the taller, more productive grasses. Such sites can carry more livestock than the shallow and droughty sites. Sandy lands require more intense management than the heavy clay soils.

On range sites, the original, or climax, vegetation is considered the most productive combination of plants that will maintain itself under natural range conditions. Continuous excessive grazing alters this original plant cover and lowers productivity. The livestock seek out

[3] ROY M. SMITH, soil scientist, Oklahoma Agricultural Experiment Station, assisted in preparing this subsection.

[4] By HARLAND E. DIETZ, range conservationist, Soil Conservation Service.

TABLE 2.—*Predicted average yields per acre of principal crops under dryland farming*

[Yields in columns A are those obtained over a period of years under common management; yields in columns B are those to be expected under improved management. Absence of yield figure indicates that the soil is not suited to the crop specified or that the crop is not commonly grown]

Soil	Wheat		Barley		Grain sorghum		Forage sorghum[1] (oven dry weight)		Alfalfa		Bermuda-grass	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Animal-unit-months*[2]	*Animal-unit-months*[2]
Bethany silt loam, 0 to 1 percent slopes	20	32	32	45	35	50	2.5	3.5	1.8	2.8	4.4	6.8
Brewer silty clay loam	20	32	32	45	40	55	3.0	4.0	2.5	3.5	5.5	7.0
Carr fine sandy loam	20	28	30	40	32	45	2.8	3.5	2.5	3.2	4.5	7.5
Carwile-Pratt complex, undulating	14	20	18	28	22	35	1.5	2.5	—	—	—	—
Dale clay loam	22	35	35	50	40	55	3.0	4.2	2.5	4.0	5.5	9.0
Dale silt loam	22	35	35	50	40	55	3.0	4.5	2.5	4.0	5.5	9.0
Dougherty-Eufaula complex, 0 to 3 percent slopes	10	18	16	25	19	33	1.8	2.8	—	—	4.0	6.0
Dougherty-Eufaula complex, 3 to 8 percent slopes	8	13	12	20	14	26	1.5	2.5	—	—	3.0	4.5
Humbarger loam	22	32	35	45	38	50	3.0	4.0	2.8	3.5	5.5	9.0
Kaw silty clay loam	24	35	35	45	40	55	3.0	4.5	3.0	4.0	5.5	9.0
Kaw silt loam	24	35	35	45	40	55	3.0	4.5	3.0	4.0	5.5	9.0
Kirkland silt loam, 1 to 3 percent slopes	16	24	22	35	20	35	1.5	2.5	—	—	2.4	4.0
Kirkland-Renfrow complex, 2 to 5 percent slopes, eroded	12	18	20	30	—	—	—	—	—	—	—	—
Labette clay loam, 5 to 8 percent slopes	12	20	20	30	—	—	—	—	—	—	—	—
Labette-Slickspots complex, 3 to 5 percent slopes, eroded	10	16	17	25	—	—	—	—	—	—	—	—
Lela clay	16	24	26	36	28	38	2.5	3.5	1.5	2.5	2.4	4.0
Lela-Slickspots complex	14	20	20	30	22	30	2.0	2.5	—	—	2.0	3.0
Lincoln soils	—	—	—	—	—	—	—	—	—	—	3.2	4.5
McLain silt loam	22	35	35	50	40	55	3.0	4.2	2.5	4.0	5.5	9.0
McLain silty clay loam	20	30	32	45	32	45	3.0	4.0	2.5	3.5	5.0	8.0
Miller clay	16	24	26	36	28	38	2.5	3.5	1.5	2.5	3.6	5.2
Newtonia silt loam, 0 to 1 percent slopes	20	32	32	45	36	52	3.0	4.2	2.0	3.2	4.5	7.0
Newtonia silt loam, 1 to 3 percent slopes	18	28	30	42	32	44	2.5	3.5	1.5	2.8	4.2	6.8
Newtonia silt loam, 3 to 5 percent slopes	16	24	24	36	22	34	2.0	2.8	—	—	3.8	6.2
Newtonia clay loam, 3 to 5 percent slopes, eroded	14	22	22	30	—	—	1.8	2.5	—	—	2.5	5.0
Norge loam, 0 to 1 percent slopes	20	32	30	45	35	50	2.8	4.2	2.0	3.2	4.5	7.0
Norge loam, 1 to 3 percent slopes	18	28	28	42	32	44	2.5	3.5	1.5	2.8	4.2	6.8
Norge loam, 3 to 5 percent slopes	16	24	24	36	23	36	2.0	2.8	—	—	3.8	6.2
Norge loam, 3 to 5 percent slopes, eroded	14	22	22	30	—	—	1.8	2.5	—	—	2.5	5.0
Norge loam, 5 to 8 percent slopes	12	20	20	30	—	—	—	—	—	—	2.5	5.2
Norge loam, 5 to 8 percent slopes, eroded	9	16	16	24	—	—	—	—	—	—	2.0	4.0
Norge-Albion complex, 3 to 5 percent slopes	13	20	20	25	18	30	1.5	2.2	—	—	3.0	5.0
Port soils, frequently flooded	—	—	—	—	—	—	—	—	—	—	4.5	8.0
Port silt loam	22	35	35	45	40	55	3.0	4.5	3.0	4.0	5.5	9.0
Pratt loamy fine sand, hummocky	10	14	15	20	15	26	1.5	2.5	—	—	—	—
Reinach loam, 0 to 1 percent slopes	20	32	32	45	35	50	3.0	4.2	2.5	3.5	5.5	8.0
Reinach loam, 3 to 8 percent slopes	12	18	18	25	20	30	1.7	2.5	—	—	4.8	6.5
Renfrow-Kirkland silt loams, 3 to 5 percent slopes	12	18	20	30	—	—	—	—	—	—	1.5	3.0
Shellabarger fine sandy loam, 1 to 3 percent slopes	16	25	22	35	28	40	2.2	3.2	1.5	2.5	4.5	7.0
Shellabarger fine sandy loam, 3 to 5 percent slopes	13	20	20	30	25	35	1.5	2.5	—	—	3.5	6.5
Shellabarger fine sandy loam, 5 to 8 percent slopes	11	17	17	25	18	28	1.4	2.2	—	—	3.0	5.5
Summit silty clay loam, 1 to 3 percent slopes	20	28	28	40	28	38	2.5	3.2	1.7	2.5	4.2	6.8
Summit silty clay loam, 3 to 5 percent slopes	16	23	24	34	22	32	2.0	2.5	—	—	3.8	6.2
Summit silty clay, 3 to 5 percent slopes, eroded	14	20	20	26	—	—	—	—	—	—	2.0	3.5
Tabler silt loam, 0 to 1 percent slopes	17	26	25	35	25	35	2.2	3.0	—	—	—	—
Vanoss silt loam, 0 to 1 percent slopes	22	34	35	50	40	55	3.0	4.5	2.2	3.5	5.5	8.0
Vanoss silt loam, 1 to 3 percent slopes	20	30	30	44	35	47	2.8	3.8	2.0	3.0	5.0	7.5
Vanoss silt loam, 3 to 5 percent slopes	16	25	24	36	25	36	2.2	2.8	—	—	4.5	7.0
Vanoss silt loam, 5 to 8 percent slopes	12	20	20	30	—	—	—	—	—	—	3.5	6.0
Vernon clay loam, 3 to 5 percent slopes	10	15	18	25	—	—	—	—	—	—	—	—
Waurika silt loam	15	22	20	32	22	32	2.0	3.0	—	—	—	—
Yahola fine sandy loam	20	28	30	40	32	45	2.8	3.5	2.5	3.2	4.5	7.5
Yahola loamy fine sand	10	16	15	25	20	28	2.2	2.8	—	—	3.5	6.5

[1] Multiply number of tons by 3 for approximate green weight.

[2] An animal-unit-month is the number of months that 1 acre will provide grazing for 1 animal, or 1,000 pounds of live weight; or it is the number of months times the number of animal units. For example, 1 acre of Port soils, frequently flooded, in a pasture of bermudagrass under improved management will provide grazing for 4 animals for 2 months and is rated 8 animal-unit-months.

the more palatable and nutritious grasses, and under heavy grazing, these choice plants, or *decreasers*, are weakened and gradually eliminated. They are replaced by less palatable plants, or *increasers*. If heavy grazing continues, even these increaser plants are weakened and the site is eventually occupied by less desirable grasses and weeds, which are called *invaders*.

The downward trend in range vegetation is generally systematic under heavy grazing and can be expressed as range condition. Four classes of range condition are recognized, *excellent*, *good*, *fair*, and *poor*. On range in excellent condition 76 to 100 percent of the plant cover consists of the original vegetation. Range in good condition has a plant cover such that 51 to 75 percent of the vegetation is that originally on the site. On range in fair condition, 26 to 50 percent of the vegetation is that originally on the site; and on range in poor condition, 25 percent or less of the original, or climax, vegetation remains. If range is in poor condition, the bulk of the vegetation is made up of weak increasers and invaders.

Descriptions of range sites

The soils of Kay County have been grouped into range sites according to their ability to produce similar kinds and amounts of climax vegetation. The description of each range site gives the more important characteristics of the soils and the names of the principal plants. To find the names of the soils in any given unit, refer to the "Guide to Mapping Units" at the back of this soil survey.

ALKALI BOTTOM-LAND RANGE SITE

Only the slickspots in Lela-Slickspots complex is in this range site. The site is on level to slightly depressional bottom lands, where it occurs with the Heavy Bottomland range site. Slickspots have a heavy clay subsoil that contains much alkali. Surface drainage is generally somewhat poor.

The decreasers on this site include switchgrass, knotroot bristlegrass, western wheatgrass, vine-mesquite, and wildrye. The increasers are blue grama, buffalograss, windmillgrass, alkali sacaton, inland saltgrass, and pricklypear. Annuals invade this site as the condition of the range worsens.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 4,000 pounds per acre in years of favorable moisture and 1,000 pounds in years of unfavorable moisture.

CLAYPAN PRAIRIE RANGE SITE

This range site occurs throughout the western two-thirds of the county. It consists of level to gently sloping upland soils. These soils have a heavy clayey subsoil that absorbs water slowly and restricts the growth of roots. If rainfall is below average, these soils are droughty.

The original vegetation on this site consisted mainly of big bluestem, little bluestem, switchgrass, and indiangrass. Overgrazing, especially during prolonged droughts, has rapidly depleted the climax vegetation. The tall grasses have been replaced by meadow dropseed, blue grama, sideoats grama, buffalograss, (fig. 18) and other less productive grasses. Blue grama, buffalograss, and dotted gayfeather are dominant in depressions that are scattered in a few areas throughout this site but are generally in Tabler silt loam, 0 to 1 percent slopes, and Waurika silt loam.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 4,500 pounds per acre in years of favorable moisture and 2,000 pounds per acre in years of unfavorable moisture.

DEEP SAND RANGE SITE

Most of this range site is along the Salt Fork Arkansas River. The soils are deep sands that absorb water rapidly but hold only a fair amount available for plants.

This site is moderately productive where the forage consists of deep-rooted climax grasses, such as sand bluestem, indiangrass, switchgrass, little bluestem, and sand lovegrass. By continued overgrazing, the production of forage is sharply reduced because there is an increase in shorter, shallow-rooted grasses. Important increasers on this site are blue grama, Texas bluegrass, prairie sagewort, and sand plum. The common invaders are sand dropseed, mat sandbur, and red lovegrass.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 5,000 pounds per acre in years of favorable moisture and 2,000 pounds per acre in years of unfavorable moisture.

DEEP SAND SAVANNAH RANGE SITE

This range site occurs along the Arkansas River in the southeastern part of the county. It consists of deep sand that absorbs water so rapidly that little runs off. The subsoil holds only a fair amount of moisture available for plants.

The climax vegetation on this site is of the savannah type and consists of productive grasses in the understory of open stands of oak trees. Big bluestem, little bluestem, indiangrass, switchgrass, and sand lovegrass are the principal decreasers. Grasses that increase under heavy grazing are purpletop, Scribner panicum, and blue grama. Under continued heavy grazing and after uncontrolled fires, blackjack and post oaks gradually increase and only a sparse stand of grass remains. Weedy invaders include mat sandbur, sand dropseed, annual threeawn, and ragweed.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 4,000 pounds per acre in years of favorable moisture and 1,800 pounds per acre in years of unfavorable moisture.

DUNE RANGE SITE

Only Sand dunes, Lincoln material, is in this range site, which occurs mainly along the Salt Fork Arkansas River in the southern part of the county. The dunes consist of deep sand that absorbs water readily but holds little available for plants.

The principal decreasers on this site are sand bluestem, little bluestem, switchgrass, indiangrass, and sand lovegrass. Where these deep-rooted grasses are grazed out, production is sharply reduced. There is an increase of sand plum and of less productive forage plants, such as Texas bluegrass, tall dropseed, sand dropseed, and prairie sagewort. Plants that commonly invade the site are mat sandbur, red lovegrass, and common witchgrass. Careful management of grazing is needed to prevent wind erosion, including blowouts (fig. 19).

Figure 18.—Kirkland silt loam, 1 to 3 percent slopes, in Claypan Prairie range site in poor condition. The vegetation is mainly buffalograss and annual three-awn. Cattle graze this site until pastures consisting of wheat and sudangrass are available.

Where the site is in excellent condition, the average annual yield of air-dry herbage is 3,200 pounds per acre in years of favorable moisture and 1,200 pounds per acre in years of unfavorable moisture.

ERODED CLAY RANGE SITE

Only Eroded clayey land is in this range site. This is land that was formerly cultivated, but cultivation has been abandoned because water erosion has been severe. Much of the surface layer has been removed, and gullies are common.

Originally big bluestem, switchgrass, indiangrass, and other tall grasses grew on this site, but less productive grasses came in after cultivation was abandoned. The main grasses now on this site are silver bluestem, meadow dropseed, windmillgrass, and annual three-awn. In many areas the seeding of adapted native grasses is needed so that further erosion is controlled

Where this site is in excellent condition, the average annual yield of air-dry herbage is 1,000 pounds per acre in years of favorable moisture and 400 pounds per acre in years of unfavorable moisture.

HEAVY BOTTOM-LAND RANGE SITE

This range site occurs mainly on wide level bottom lands (fig. 20) along the Chikaskia River and Birds Nest Creek. It consists of deep clays and silty clay loams that absorb water slowly. Production is high during years of abundant rainfall, but it drops sharply during periods of drought.

The dominant climax grasses on this site are big bluestem, switchgrass, prairie cordgrass, indiangrass, eastern gramagrass, Canada wildrye, and little bluestem. The principal increasers are tall dropseed, knotroot bristlegrass, western wheatgrass, vine-mesquite, and sideoats grama. Plants that invade the site are silver bluestem, windmillgrass, buffalograss, ironweed, and ragweed. The common woody plants are elm, hackberry, walnut, pecan, and coralberry. These plants increase abundantly in areas that are overgrazed.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 6,000 pounds per acre in years of favorable moisture and 3,500 pounds per acre in years of unfavorable moisture.

LOAMY BOTTOM-LAND RANGE SITE

This range site occurs on level to sloping bottom lands along the rivers and other large streams in the county. The site consists of deep loamy soils that have a high capacity for storing moisture and plenty of room for the growth of roots. It is the most productive range site in the county.

Where the range is in excellent condition, tall and midgrasses that grow in warm seasons are dominant on this site. Among these grasses are big bluestem, eastern grama, indiangrass, Florida paspalum, little bluestem, and switchgrass. Overgrazing causes an increase in tall dropseed, purpletop, western wheatgrass, and knotroot bristlegrass, as well as an increase in woody plants. The common invaders include ironweed, ragweed, silver bluestem, and buffalograss.

The trees on this site, mainly woody elm, cottonwood, oak, and pecan, grow naturally along streambanks. Under the canopy of these trees are Canada wildrye, Virginia wildryes, and other shade-tolerant, cool-season grasses.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 8,500 pounds per acre in years of favorable moisture and 4,500 pounds per acre in years of unfavorable moisture.

Figure 20.—In background, Lela clay in the Heavy Bottom-land range site in excellent condition. The Alkali Bottom-land range site is in foreground.

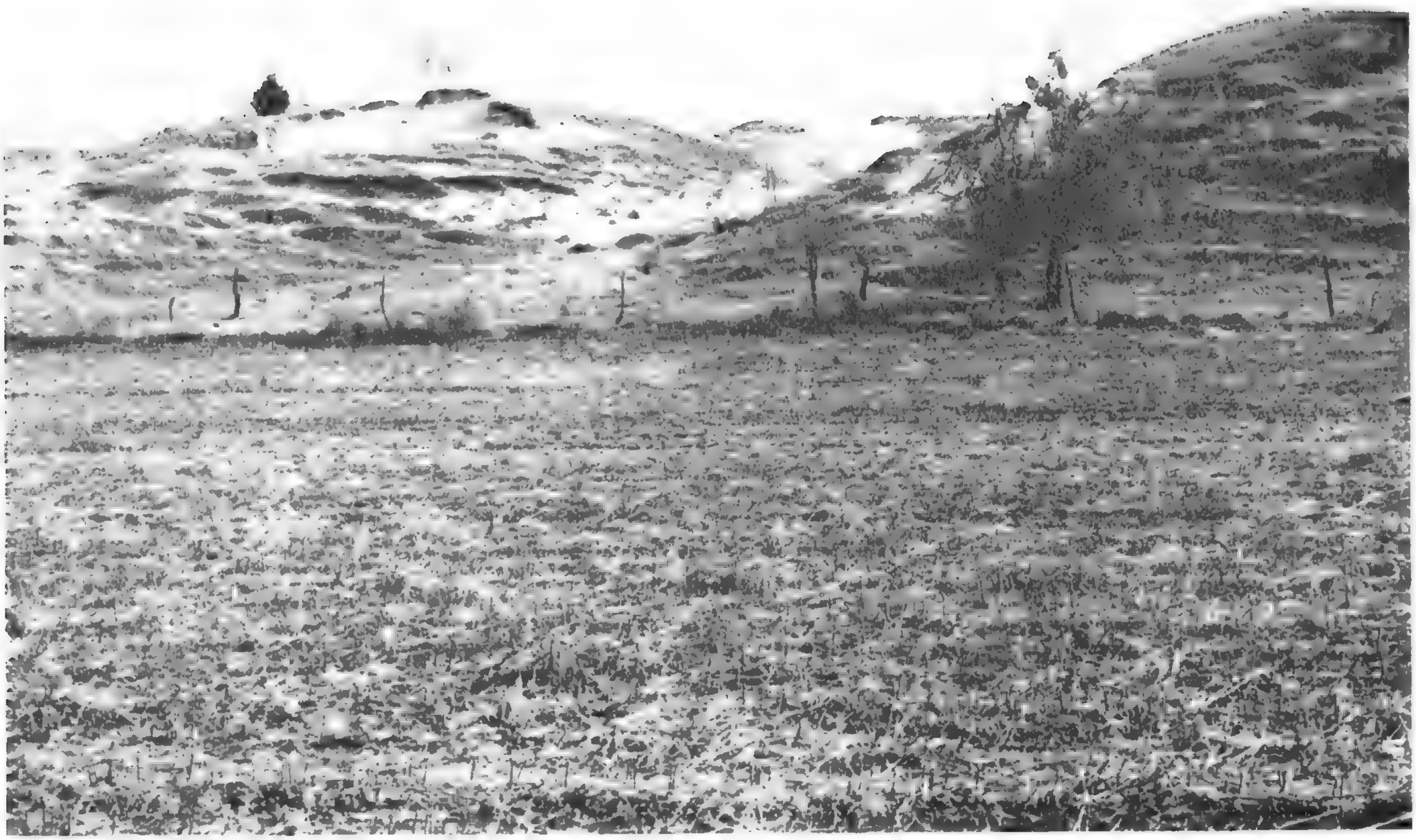

Figure 19.—Dune range site in background and Sandy Bottom-land range site in foreground. The light-colored, blowout spots are the result of overgrazing by livestock. A mixture of native grasses is to be drilled into the noncompetitive cover crop on Yahola loamy fine sand in foreground.

LOAMY PRAIRIE RANGE SITE

This range site consists of moderately deep or deep soils on nearly level to steep uplands. These soils are generally fertile and productive. They have a permeable subsoil that allows moisture to penetrate readily and that provides ample room for roots to grow.

Big bluestem, little bluestem, indiangrass, switchgrass, and other tall productive grasses are dominant where this range site is in excellent condition (fig. 21.) If the site is overgrazed, these decreasers are replaced by tall dropseed, Scribner panicum, sideoats grama, blue grama, and other less productive grasses. Weeds that commonly invade heavily grazed areas are western ragweed, broomweed, ironweed, old field three-awn, and coralberry.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 6,000 pounds per acre in years of favorable moisture and 3,000 pounds per acre in years of unfavorable moisture.

RED CLAY PRAIRIE RANGE SITE

This range site consists of gently sloping to strongly sloping, shallow clays to clay loams that are underlain by interbedded shale. The shale is exposed in many areas on the steeper slopes.

The dominant decreaser on this site is little bluestem, but big bluestem, indiangrass, and switchgrass occur in small amounts. As condition of the range declines, sideoats grama, blue grama, hairy grama, and buffalograss increase. Continuous close grazing reduces plant cover and increases erosion.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 3,000 pounds per acre in years of favorable moisture and 1,200 pounds per acre in years of unfavorable moisture.

SANDY BOTTOM-LAND RANGE SITE

This range site consists of deep sands on level to nearly level bottom lands (fig. 22) along the Arkansas and Salt Fork Arkansas Rivers. These soils are subject to floods during which coarse to fine sands are occasionally deposited. In many places deep-rooted plants are subirrigated at a depth ranging from 4 to 8 feet.

The dominant decreasers in the climax vegetation are sand bluestem, indiangrass, switchgrass, prairie cordgrass, little bluestem, and Canada wildrye. Open stands of willow, cottonwood, hackberry, and elm also are common.

Stands of timber thicken in overgrazed areas, and purpletop, tall dropseed, blue grama, and sideoats grama increase in amount. Where flooding and siltation are frequent, johnsongrass is a persistent invader.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 5,500 pounds per acre in years of favorable moisture and 3,000 pounds per acre in years of unfavorable moisture.

Figure 21.—Vanoss silt loam, 1 to 3 percent slopes, in the Loamy Prairie range site in excellent condition.

Figure 22.—**Yahola loamy fine sand in the Sandy Bottom-land range site in excellent condition. Because of the water table, deep-rooted grasses grow well.**

SANDY PRAIRIE RANGE SITE

In this range site are nearly level to sloping soils on uplands. These soils have a loamy surface layer that takes in water well and a sandy clay loam to clay subsoil that stores a large amount of moisture. This site is productive when it is in good or excellent condition. Much of the climax vegetation consists of tall grasses, mainly big bluestem, indiangrass, switchgrass, and little bluestem. The principal increasers are tall dropseed, blue grama, and sand paspalum. Common invaders when the site is in poor condition are sand dropseed, mat sandbur, and western ragweed. In the eastern part of the county, a few oak trees dot this site, and they increase in number if range management is poor.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 5,000 pounds per acre in years of favorable moisture and 2,500 pounds per acre in years of unfavorable moisture.

SLICKSPOT RANGE SITE

Only Slickspots in the mapping unit Labette-Slickspots complex, 3 to 5 percent slopes, eroded, is in this range site. The site occupies gently sloping uplands. At a depth of 2 to 4 inches is a blocky clay layer that generally contains some alkali. This layer retards productivity by restricting the penetration of roots and water.

In the northeastern part of the county, this range site commonly occurs with the Loamy Prairie range site.

If this site is in excellent condition, short grasses, mainly blue grama, are dominant in the vegetation, and there are small scattered amounts of switchgrass, little bluestem, big bluestem, and tall dropseed. If the site is in poor condition, the invaders are fall witchgrass, old field three-awn, western ragweed, pricklypear, and other plants.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 1,000 pounds per acre in years of favorable moisture and 500 pounds per acre in years of unfavorable moisture.

VERY SHALLOW RANGE SITE

This range site consists of very shallow soils on nearly level ridges or steep breaks in the eastern part of the county. In most places limestone bedrock is at a depth of 10 inches or less, and the space for moisture storage and root growth is limited.

Short grasses are dominant on this site. These grasses are mainly blue grama, hairy grama, and sideoats grama, and there is a small amount of little bluestem. Overgrazing results in an increase in buffalograss, tumble windmillgrass, silver bluestem, and various annual plants.

In a few places, deep crevices or pockets in the limestone bedrock contain soil material that supports the taller grasses that are generally on the Loamy Prairie range site. These grasses are mainly big bluestem, indiangrass, switchgrass, and little bluestem.

Where this site is in excellent condition, the average annual yield of air-dry herbage is 2,000 pounds per acre in years of favorable moisture and 500 pounds per acre in years of unfavorable moisture.

Management of Woodland for Windbreaks and Post Lots [5]

The native woodland in Kay County is on bottom lands along the Arkansas, Salt Fork Arkansas, and Chikaskia Rivers and numerous smaller streams. Cottonwood and willow are the most common trees on the sandy river bottoms, and elm, hackberry, red oak, ash, walnut, and pecan grow along streams in the higher areas. Blackjack and post oaks grow along the Arkansas River in areas of Dougherty-Eufaula complex that have not been cleared for crops or improved for range. The main trees used commercially are black walnut and pecan.

The soils of Kay County that are suitable for windbreaks, post lots, and woodland have been placed in four woodland suitability groups, as shown in the "Guide to Mapping Units" at the back of this soil survey. Following are the descriptions of the four groups. For the soils of each group, the rating of suitability is based on the height, vigor, and condition of the trees at 20 years of age.

WOODLAND SUITABILITY GROUP 1

This woodland suitability group consists of deep, nearly level to very gently sloping soils on bottom lands and uplands. These soils are well drained, have a high capacity for storing moisture, and have slow to medium runoff.

The soils of this group are good to excellent for growing trees in farmstead windbreaks and post lots.

Tall trees suitable for windbreaks are Siberian elm, cottonwood, and sycamore. Elm grows best in the loams and fine sandy loams and may reach a height of 75 feet in 20 years. Cottonwood and sycamore are more suited to the moderately coarse textured soils. In 20 years or less, the cottonwoods may reach a height of 85 to 90 feet but the sycamores seldom grow higher than 75 feet.

[5] HERBERT R. WELLS, woodland conservationist, assisted in the preparation of this subsection.

Russian mulberry can be used as a tree of intermediate height or, where the tall trees are cottonwood and sycamore, as the understory. If closely spaced, 4 feet in the row, Russian mulberry makes an excellent shrub.

The evergreens Austrian pine, ponderosa pine, eastern redcedar, and some strains of the seedling (nongrafted) form of Chinese arborvitae are suitable as tall trees in farmstead windbreaks. These evergreens are also suitable in a field windbreak if they are used in a shrub row and other trees are used as tall trees. Austrian and ponderosa pines generally are not more than 25 to 35 feet high at the age of 20 years. Redcedar and arborvitae reach 30 to 35 feet in a 20-year period.

Common species suitable for posts that do well on these soils are black locust, catalpa, and Osage-orange. Osage-orange is the best suited of the three on the heavier soils of this group, such as Brewer and McLain silty clay loams. All three of these species average at least a six-post tree in 20 years, but they give a higher return if they are selectively cut when 8 to 12 years of age, and if the sprouts are then managed for sustained yields.

WOODLAND SUITABILITY GROUP 2

This woodland suitability group consists of deep, nearly level to steep, medium-textured and coarse-textured soils on bottom lands and uplands. These soils are somewhat poorly drained to excessively drained.

The soils of this group are generally fair to good for windbreaks and post lots. The exceptions are Breaks-Alluvial land complex, Broken alluvial land, and Loamy broken land, and the Lincoln, Port, Reinach, and Yahola soils. These alluvial and upland soils occur mainly in odd areas that are suitable for post lots but are not in positions where windbreaks are needed.

The soils of this group differ from those of group 1 mainly in having less desirable moisture relationships in the subsoil. Suitable tall trees are Siberian elm, cottonwood, and sycamore. In the first 20 years, these tall trees average 10 to 20 feet less growth than on the soils of group 1. Trees of intermediate height, such as Russian mulberry, ponderosa pine, and eastern redcedar, make 5 to 10 percent less growth in 20 years than they do on the soils of group 1. Essentially the same is true for black locust, catalpa, and Osage-orange, the species grown for posts.

WOODLAND SUITABILITY GROUP 3

This woodland suitability group consists of shallow and deep soils that are slightly depressional to sloping. These soils are medium textured to fine textured and range from permeable to very slowly permeable. Surface runoff is slight to excessive.

These soils have limitations that make them generally unsuitable as sites for field windbreaks or post-lot plantings. Vernon clay loam, 3 to 5 percent slopes, is generally too shallow over compact clay for trees. The Kirkland, Renfrow, Summit, and Tabler soils are deep but have a clayey subsoil and a slow rate of moisture replenishment. Excessive runoff limits the use of Labette, Norge, Shellabarger, and Vanoss soils that have slopes of 5 to 8 percent. Erosion is the main limitation of other soils in this group. Farmstead windbreaks (fig. 23) are practical where no great height is needed and where the trees can be watered from the farm supply during droughty periods.

Siberian elm is the best adapted tall tree for these soils. In the first 20 years, this elm seldom exceeds 40 to 45 feet in height, but it grows rapidly during the first several years and provides early protection to farmsteads. Russian mulberry also grows quite rapidly in early life, but it averages only 30 to 35 feet high in 20 years.

Eastern redcedar and Chinese arborvitae are also suitable for these soils. After 20 years they are the most valuable trees in a windbreak because their forage is evergreen and they are long lived. Their early rate of growth is slow, however, for they average only 20 to 25 feet in the first 20 years. Austrian and ponderosa pines are also adapted but are even slower in reaching an effective height.

WOODLAND SUITABILITY GROUP 4

The soils in this woodland suitability group range from shallow to deep, from nearly level to steep, and from medium acid to moderately saline. They range from noneroded to severely eroded. These soils occur on both bottom lands and uplands.

These soils are not suitable for tree plantings or for woodlands. Miscellaneous adverse characteristics limit the survival and growth of trees. The soils are unsuitable, mainly because they are saline, eroded, and shallow.

Wildlife and Fish [6]

The wildlife habitats in Kay County occur generally in those areas that are not intensively cultivated. The main areas are in the prairie uplands east of Newkirk; on the timbered, narrow bottom lands along streams and drainageways; and in small areas of timbered uplands along the Arkansas River.

The important species of wildlife in Kay County are bobwhite quail, mourning dove, waterfowl, fox squirrel, cottontail rabbit, jackrabbit, raccoon, fox, mink, opossum, skunk, muskrat, and coyote. Wild turkey and deer have been stocked in the county, and indications are that the stocking has been successful. Pheasant also have been stocked in the county, but only small numbers of these birds survive. They are in the central and western parts of the county. Greater prairie chicken in fair numbers inhabit the grassland areas in the eastern part of the county. Many kinds of songbirds occur throughout the county. The main predators are fox, coyote, and bobcat. Predatory birds are hawks and owls.

A convenient way to discuss areas of the county as wildlife habitat is by soil associations. The soil associations in the county are described in the section "General Soil Map."

The Kaw-Brewer-Reinach-Lela (1) and the Yahola-Lincoln (2) soil associations consist mainly of alluvial soils along the major streams that cross the county from north to south. These associations make up about 22 percent of the county. They consist of nearly level, fertile soils that are well suited to many kinds of crops and are intensively cultivated in large areas. Most of the acreage is cultivated, and only a small part remains in trees or grass and is suitable as wildlife habitat. The acreage in trees or grass is generally in rough areas along

[6] By JEROME F. SYKORA, biologist, Soil Conservation Service.

Figure 23.—**A well-planned windbreak on Tabler silt loam, 0 to 1 percent slopes, in woodland suitability group 3.**

streams or in other places not suitable for cultivated crops. In these areas the woody plants that provide food and cover for wildlife are oak, hackberry, cottonwood, mulberry, elm, soapberry, pecan, walnut, and many kinds of shrubs and vines, such as sumac, plum, and greenbriers. Grasses important as wildlife food and cover are bluestem, switchgrass, indiangrass, johnsongrass, and various annuals. Several kinds of native legumes and forbs also supply food and cover.

Although the areas suitable as wildlife habitat are not large, they provide desirable food at the edge of wooded areas, and the food is eaten by fox squirrels, deer, cottontail rabbits, quail, turkeys, and songbirds. The sandy Lincoln soils and Broken alluvial land are particularly valuable for wildlife because they are not suitable for cultivation, and they support many kinds of plants suitable for food and cover.

The Kirkland-Tabler-Bethany association (3) makes up 38 percent of the county and consists of soils that are intensively cultivated to small grains and sorghum. Most of this association is cultivated, and only the small areas of grass and woody plants along streams and drainageways are suitable habitat for wildlife. The areas are inhabited by quail, rabbits, and squirrels. Large numbers of jackrabbits frequent the cultivated fields.

The Shellabarger-Dougherty-Eufaula association (4) occupies only about 2 percent of the county, but it lies next to wooded bottom land that is good habitat for wildlife. The association consists of deep, permeable soils that provide a good supply of food for the wildlife living in the wooded bottom land. Among the plants that furnish food for wildlife are blackjack oak, cottonwood, elm, soapberry, walnut, pecan, plum, mulberry, and many annual and perennial legumes, grasses, and forbs.

The Norge-Vanoss association (5) consists of loamy soils of the prairie that are well suited to cultivated crops, mainly small grains and sorghum. The association makes up about 13 percent of the county. Most of the acreage is intensively cultivated, and little habitat suitable for wildlife remains. Some species of waterfowl eat the waste grain in the sorghum fields and the green forage in the wheatfields. Some areas along small wooded streams and drainageways in the uplands are suitable for squirrels, rabbits, quail, and other small game.

The Owens-Vernon soil association (6) consists of shallow, generally infertile soils of the uplands that make up only about 2 percent of the county. These soils provide only a few small wildlife areas, and these are frequented by upland game, mainly quail, jackrabbits, and cottontail rabbits. These areas are poor as wildlife habitat because the native vegetation is mainly weeds and only a few cultivated areas are nearby.

The Newtonia-Summit-Sogn soil association (7) consists of deep and shallow soils that occupy uplands in the eastern third of the county. The association makes up about 9 percent of the county. A little more than half of the acreage is cultivated to alfalfa, small grains, and

sorghum. The cultivated fields are not large, and on nearly every farm, there are some grassland and some wooded areas along creeks and in ravines. These areas provide fair to good habitat for deer, turkeys, quail, rabbits, greater prairie chickens, and songbirds.

The Sogn-Summit-Labette soil association (8) makes up about 14 percent of the county and lies along the eastern boundary. It consists of shallow and deep, rolling soils underlain by limestone. About 10 percent of the association is cultivated to small grains, sorghum, and alfalfa, and much of the rest is in tall grasses of good quality. The association is dissected by numerous ravines and drainageways, in which many woody and shrubby plants grow. Habitat is good for deer, quail, turkeys, squirrels, rabbits, furbearers, and songbirds. Greater prairie chickens frequent the well-managed range, the wooded ravines, and the adjacent cropland.

Many farm ponds have been built in the county to furnish water for livestock, but the ponds built in intensively cultivated areas produce only a small amount of fish. Runoff is mainly from cropland, and the water in the ponds is turbid most of the time. Channel catfish is the most suitable species in these turbid ponds. Ponds built in alluvial soil and soils derived from limestone are clean most of the time if their water is runoff from a protected watershed. These ponds can be successfully stocked with bass, bluegill, and channel catfish. If ponds are built in sandy alluvial soils, care is needed to insure that the soils are impermeable enough to hold water.

Use of Soils in Engineering[7]

Some soil properties are of special interest to engineers because they affect the construction and maintenance of roads, airports, pipelines, building foundations, water storage facilities, erosion control structures, drainage systems, and sewage disposal systems. The properties most important to the engineer are permeability to water, shear strength, compaction characteristics, soil drainage, shrink-swell characteristics, grain size, plasticity, and reaction. Also important are topography, depth to water table, and depth to bedrock.

Information in this survey can be used to—

1. Make soil and land use studies that will aid in selecting and developing sites for industries, businesses, residences, and recreational areas.
2. Make preliminary estimates of the engineering properties of soils in the planning of agricultural drainage systems, farm ponds, irrigation systems, and diversion terraces.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting locations for highways, airports, pipelines, and cables and in planning detailed investigations at the selected locations.
4. Locate probable sources of gravel and other construction materials.
5. Correlate performance of engineering structures with soil mapping units and thus develop information that will be useful in designing and maintaining the structures.
6. Determine the suitability of soil mapping units for cross-country movement of vehicles and construction equipment.
7. Supplement the information obtained from other published maps and from reports and aerial photographs for the purpose of making maps and reports that can be used readily by engineers.
8. Develop other preliminary estimates for construction purposes pertinent to the particular area.

With the use of the soil map for identification, the engineering interpretations in this subsection can be useful for many purposes. It should be emphasized that they may not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads or where the excavations are deeper than the depths of layers here reported. Even in these situations, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Much of the information in this section is given in tables 3, 4, and 5. In table 3 properties of the soils that are important to engineering are estimated. Table 4 indicates the suitability of the soils for various engineering uses. Table 5 contains test data for soils of seven series in the county.

In addition to this subsection, "Descriptions of the Soils," "How Soils Are Formed and Classified," and other sections of the soil survey are useful to engineers. Some of the terms used by the soil scientist may be unfamiliar to engineers, and some terms have a special meaning in soil science. These terms, as well as other terms used in this soil survey, are defined in the Glossary.

Engineering classification systems

Two systems of classifying soils are in general use among engineers. One is the system approved by the American Association of State Highway Officials (AASHO) (*1*), and the other is the Unified system adopted by the Corps of Engineers, U.S. Army (*8*). Both systems are used in this survey and are explained in the following paragraphs. The explanations are taken largely from the PCA Soil Primer (*3*).

AASHO classification system.—Most highway engineers classify soils according to the AASHO system. In this system, soils are placed in seven principal groups. The groups range from A–1, consisting of gravelly soils of high bearing capacity, to A–7, consisting of clay soils that have low strength when wet. Within each group, the relative engineering value of the soil material is indicated by a group index number. Group index numbers range from 0 for the best material to 20 for the poorest. For the soils tested, the group index numbers are shown in table 5 in parentheses following the soil group symbol. The estimated AASHO classification of the soils in the county, without group index numbers, is given in table 3.

Unified classification system.—In the Unified classification system, the soils are grouped on the basis of their texture and plasticity and their performance as material for engineering structures. Soil materials are identified as gravels (G), sands (S), silts (M), clays (C), organic soils (O), and highly organic soils (Pt). In this system clean sands are identified by the symbols

[7] CECIL E. WILDMAN and WILLIAM E. HARDESTY, civil engineers, and MELVIN BURRIS, agricultural engineer, Soil Conservation Service, helped prepare this subsection.

SW and SP; sands mixed with fines of silt and clay are identified by the symbols SM and SC; silts and clays that have a low liquid limit are identified by the symbols ML and CL; and silts and clays that have a high liquid limit are identified by the symbols MH and CH. The tested soils are classified according to the Unified system in table 5, and the classification for the soils that were not tested is estimated in table 3.

Estimated engineering properties of soils

Table 3 provides estimates of some properties of soils that affect engineering. The estimates are for a modal profile or for a profile typical of the soil series or soil type. For the soils in the county that were tested, estimates in table 3 are based on the test data listed in table 5. For other soils, estimates are based on test data obtained from similar soils in this county and in other counties and on past experience in engineering. Since the estimates are for typical profiles, variations from the estimates may be considerable. Following are explanations of the columns in table 3.

Hydrologic soil groups are groups of soils having similar rates of infiltration, when wetted, and similar rates of water transmission within the soil. Four such groups currently are recognized.

Soils in group A have a high infiltration rate, even when thoroughly wetted. They have a high rate of water transmission and low runoff potential. The soils of this group are deep, are well drained or excessively drained, and consist chiefly of sand, gravel, or both.

Soils in group B have a moderate infiltration rate when thoroughly wetted. Their rate of water transmission and their runoff potential are moderate. These soils are moderately deep or deep, are moderately well drained or well drained, and are of fine to moderately coarse texture.

Soils of group C have a slow infiltration rate when thoroughly wetted. Their rate of water transmission is slow, and their potential runoff is high. These soils have a layer that impedes the downward movement of water, or they are moderately fine or fine textured and have a slow infiltration rate.

Soils of group D have a slow infiltration rate when thoroughly wetted. Their rate of water transmission is very slow, and runoff potential is very high. In this group are (1) clay soils with high shrink-swell potential; (2) soils with a permanent high water table; (3) soils with a claypan or clay layer at or near the surface; and (4) soils shallow over nearly impervious material.

Permeability relates to movement of water downward through undisturbed soil. The estimates in table 3 are for the soil as it occurs in place and are based on soil structure and porosity. Plowpans, surface crusts, and mechanically created restrictions on permeability are not considered in estimating permeability. The ratings given for permeability in table 3 are defined in the Glossary.

Available water, in inches per inch of soil depth, is the approximate amount of capillary water in the soil when it is wetted to field capacity. When this soil is at the wilting point of common plants this amount of water will wet the soil to a depth of 1 inch without deeper percolation.

Reaction is expressed in terms of pH values. A pH of 4.5 to 5.0 indicates very strong acidity, and a pH of 9.1 or higher indicates very strong alkalinity.

Shrink-swell potential refers to the change in volume of a soil that results from a change in moisture content. Estimates are based on tests for volume change or on observance of other physical properties of the soil. For example, the soil material from the B horizon of Kirkland silt loam has high shrink-swell potential because it is very sticky when wet, and it shrinks and cracks a great deal when it dries. In contrast, the entire profile of Eufaula fine sand has low shrink-swell potential because it is structureless and is nonplastic.

Engineering interpretations of soils

In table 4 the soils of Kay County are rated according to their suitability as a source of topsoil, grading material, and road fill. Also pointed out are those features affecting suitability as sites for highways, farm ponds, drainage systems, terraces and diversions, and waterways. The information in table 4 is based on the estimated engineering properties in table 3, the actual test data in table 5, and field experience with the soils.

Topsoil is presumed fertile soil or soil material, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens. The suitability of a soil as a source of topsoil depends largely on texture and depth. It is necessary that topsoil be of a texture that works to a good seedbed, yet contains enough clay to resist erosion on strong slopes. The depth of suitable material determines whether or not it is economical to use the soil for topsoil.

Select grading material has suitable grain size and favorable content of silt and clay. Soils that are primarily sands are good grading material if binder is added to increase cohesion. Clay soils in contrast, are poor grading material, because they compress under load but rebound when unloaded.

Road fill can be of almost any soil material. Sandy clays and sandy clay loams are easy to place and to compact. Clays having high shrink-swell potential, however, require special compaction and close control of moisture both during and after construction. Sands compact well but are difficult to confine in a fill. The ratings in table 4 reflect the various limitations and advantages of different kinds of soil materials.

Engineering test data

Table 5 contains the test data for soil samples collected from selected soils and tested by the Oklahoma Department of Highways. The tests were made for the purpose of determining shrinkage, volume change, liquid limit, and plasticity index. A mechanical analysis of each sample was made so that the percentage of the various-sized particles could be determined.

As moisture is removed, the volume of a soil decreases, in direct proportion to the loss of moisture, until equilibrium, called the shrinkage limit, is reached. Beyond the shrinkage limit, more moisture may be removed, but the volume of the soil does not change. In general, the lower the number listed in table. 5 for the shrinkage limit, the higher the content of clay.

The shrinkage ratio is the volume change, expressed as a percentage of the volume of dry soil material, divided by the loss of moisture caused by drying. This ratio is expressed numerically.

TABLE 3.—*Estimated*

Soils	Hydrologic soil group	Permeability [1]	Depth from surface
			Inches
Albion (NxC) (For properties of Norge soils in this mapping unit, refer to the Norge series.)	B	Moderate.	0–13 13–26 26–60
Bethany (BeA)	C	Slow.	0–16 16–37 37–60
Breaks-Alluvial land complex (Bk)	C	Very slow.	0–10 10–20 20
Brewer (Bm)	D	Slow.	0–8 8–34 34–60
Broken alluvial land (Br)	B	Moderate.	0–60
Carr (Ca)	B	Moderately rapid.	0–60
Carwile (CuB) (For properties of Pratt soils in this mapping unit, refer to the Pratt series.)	C	Slow.	0–20 20–60
Dale:			
Clay loam (Dc)	C	Moderately slow.	0–60
Silt loam (Ds)	B	Moderate.	0–60
Dougherty (DxB, DxC) (For properties of Eufaula soils in these mapping units, refer to the Eufaula series.)	B	Moderate.	0–22 22–32 32–60
Eroded clayey land (Es)	D	Very slow.	0–60
Eroded loamy land (Et)	C	Slow.	0–60
Eufaula (DxB, DxC) (For properties of Dougherty soils in these mapping units, refer to the Dougherty series.)	A	Rapid.	0–60
Humbarger (Hu)	B	Moderate.	0–14 14–60
Kaw:			
Silt loam (Ka)	B	Moderate.	0–60
Silty clay loam (Kc)	C	Slow.	0–60
Kirkland (KnB, KrC2, RkC) (For properties of the Renfrow soils in mapping units KrC2 and RkC, refer to the Renfrow series.)	D	Very slow.	0–10 10–60
Labette (LaD)	C	Moderately slow.	0–18 18–60
Labette-Slickspots complex (LbC2)	C	Slow.	0–4 4–34 34
Lela (Lc, Le)	D	Very slow.	0–60
Lincoln (Lm)	A	Rapid.	0–15 15–60
Loamy broken land (Lo)	B	Moderate.	0–60

See footnote at end of table.

properties of the soils

Classification			Percentage passing sieve—			Available water capacity	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)			
						Inches per inch of soil	*pH value*	
Sandy loam	SM, SC	A-2	100	100	20-35	0.12	5.6-6.0	Low.
Sandy clay loam	SC, CL	A-4	100	100	40-60	.14	5.6-6.0	Low to moderate.
Coarse sand	SP, GP	A-3	25-75	25-75	0-10	.05	6.1-7.3	None.
Silt loam	ML	A-4	100	100	75-90	.14	5.6-6.5	Low.
Clay	CL, CH	A-7	100	100	90-100	.17	6.6-7.3	High.
Silty clay loam	CL	A-6, A-7	100	100	85-95	.17	6.6-8.4	Moderate.
Clay loam	CL	A-6	100	100	75-95	.17	5.6-6.5	Moderate.
Clay	CL, CH	A-7	100	100	90-100	.17	6.6-8.4	High.
Shale								
Silty clay loam	CL	A-6	100	100	85-98	.17	5.6-6.5	Moderate.
Clay	CL	A-7	100	100	90-100	.17	6.6-8.4	High.
Silty clay loam	CL	A-6, A-7	100	100	85-98	.17	7.4-8.4	Moderate.
Silt loam	ML	A-4	100	100	75-90	.14	6.0-8.4	Low.
Fine sandy loam	SM	A-4, A-2	100	100	25-45	.12	7.9-8.4	Low.
Fine sandy loam	SM	A-2, A-4	100	100	20-50	.14	5.1-6.0	Low.
Clay	CL, CH	A-7	100	100	90-100	.17	6.6-8.4	High.
Clay loam	CL	A-6	100	100	75-95	.17	6.1-7.3	Moderate.
Silt loam	ML	A-4	100	100	75-90	.14	6.1-7.3	Low.
Fine sandy loam	SM	A-2	100	100	20-35	.12	5.1-6.0	Low.
Sandy clay loam	CL or SC	A-4	100	100	40-60	.14	5.6-6.0	Low to moderate.
Loamy fine sand	SM	A-2	100	100	11-30	.07	5.6-6.0	None.
Clay	CL, CH	A-7	100	100	90-100	.17	6.5-8.4	High.
Clay loam	CL	A-6	100	100	75-95	.17	6.5-8.4	Moderate.
Fine sand	SP-SM	A-3	100	100	5-10	.05	5.1-6.0	Low.
Loam	ML, CL	A-4	100	100	55-85	.14	7.4-8.4	Low.
Silt loam	ML	A-4	100	100	75-90	.14	7.4-8.4	Low.
Silt loam	ML	A-4	100	100	75-90	.14	6.1-7.3	Low.
Silty clay loam	CL	A-6	100	100	85-95	.17	6.1-7.3	Moderate.
Silt loam	ML, CL	A-4	100	100	75-98	.14	5.6-6.0	Low.
Clay	CL, MH, CH.	A-7	100	95-100	90-100	.17	6.6-8.4	High.
Clay loam	CL	A-6	100	100	75-95	.17	6.6-7.3	Moderate.
Clay	CL, CH	A-7	100	100	90-100	.17	7.4-8.4	High.
Clay loam	CL	A-6	100	100	75-95	.17	6.6-7.3	Moderate.
Clay	CL, CH	A-7	100	100	90-100	.17	7.4-8.4	High.
Limestone								
Clay	CH	A-7	100	100	90-100	.17	5.6-8.4	High.
Loamy sand	SM	A-2	90-100	90-100	15-35	.07	7.4-8.4	None.
Loamy sand and gravel	GP, SP	A-2	25-75	25-75	0-20	.05	7.4-8.4	None.
Silt loam	ML	A-4	100	100	75-90	.14	6.6-8.4	Low.

TABLE 3.—*Estimated properties*

Soils	Hydrologic soil group	Permeability [1]	Depth from surface
McLain:			*Inches*
Silt loam (MaA)	C	Moderate.	0–17 17–25 25–60
Silty clay loam (Mb)	C	Slow.	0–8 8–21 21–60
Miller (Mc)	D	Very slow.	0–19 19–29 29–60
Newtonia (NeA, NeB, NeC, NnC2)	C	Moderate.	0–9 9–44 44–60
Norge (NoA, NoB, NoC, NoC2, NoD, NoD2, NxC) (For properties of Albion soils in mapping unit NxC, refer to the Albion series.)	C	Slow.	0–8 8–60
Owens (OwE)	D	Very slow.	0–20 20–60
Port:			
Soils, frequently flooded (Pf)	B	Slow.	0–24 24–60
Silt loam (Ps)	B	Moderately slow.	0–36 36–60
Pratt (PtC, CuB) (For properties of Carwile soils in the mapping unit CuB, refer to the Carwile series.)	A	Rapid.	0–60
Reinach (RcA, RcD)	B	Moderate.	0–60
Renfrow (RkC, KrC2) (For properties of Kirkland soils in mapping unit KrC2, refer to the Kirkland series.)	D	Very slow.	0–6 6–12 12–60
Sand dunes, Lincoln material (Sa)	A	Rapid.	0–8 8–60
Shellabarger (ShB, ShC, ShD)	B	Moderate.	0–16 16–42 42–60
Sogn (SnB, SsF) (For properties of the Summit soils in the mapping unit SsF, refer to the Summit series.)	D	Moderately slow.	0–9 9
Summit (SuB, SuC, SyC2, SsF) (For properties of the Sogn soils in mapping unit SsF, refer to the Sogn series.)	C	Slow.	0–23 23–60
Tabler (TaA)	D	Very slow.	0–8 8–60
Vanoss (VaA, VaB, VaC, VaD)	B	Moderate.	0–12 12–60

See footnote at end of table.

of the soils—Continued

Classification			Percentage passing sieve—			Available water capacity	Reaction	Shrink-swell potential
USDA texture	Unified	AASHO	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)			
						Inches per inch of soil	*pH value*	
Silt loam	ML	A-4	100	100	75–90	0.14	5.6–6.0	Low.
Clay loam	CL	A-6	100	100	75–90	.17	6.1–6.5	Moderate.
Silt loam	ML	A-4	100	100	75–90	.14	6.6–7.3	Low.
Silty clay loam	CL	A-6	100	100	75–90	.17	5.6–6.0	Moderate.
Clay	CL, CH	A-7	100	100	90–100	.17	6.1–6.5	High.
Silty clay loam	CL	A-6	100	100	85–95	.17	6.6–7.3	Moderate.
Clay	CL, CH	A-7	100	100	90–100	.17	7.4–8.4	High.
Clay loam	CL	A-6, A-7	100	100	75–90	.17	7.4–8.4	Moderate.
Very fine sandy loam	ML	A-4	100	100	60–80	.14	7.4–8.4	Low.
Silt loam	ML	A-4	100	100	75–90	.14	6.1–6.5	Low.
Silty clay loam	CL	A-6	100	100	85–95	.17	6.1–6.5	Moderate.
Silty clay	CL, ML	A-7	100	100	90–100	.17	6.6–7.3	Moderate to high.
Loam	ML, CL	A-4	100	100	55–85	.14	5.6–6.0	Low.
Clay loam	CL	A-6	100	100	75–95	.17	5.6–7.3	Moderate.
Clay	CL, CH	A-7	100	100	90–100	.17	7.4–8.4	High.
Shale							7.4–8.4	
Silt loam	ML	A-4	100	100	75–90	.14	6.1–7.3	Low.
Silty clay loam	CL	A-6	100	100	85–95	.14	6.6–7.3	Moderate.
Silt loam	ML	A-4	100	100	75–90	.14	6.1–7.3	Low.
Silty clay loam	CL	A-6	100	100	85–95	.17	6.6–7.3	Moderate.
Loamy fine sand	SM	A-2	100	100	11–30	.07	5.6–6.5	None.
Loam	ML, CL	A-4	100	100	55–85	.14	6.1–8.4	Low.
Silt loam	ML	A-4	100	100	75–90	.14	6.1–6.5	Low.
Clay loam	CL	A-6	100	100	75–95	.17	6.1–7.3	Moderate.
Clay	CL, CH	A-7	100	100	90–100	.17	6.6–7.8	High.
Loamy sand	SM	A-2	90–100	90–100	15–35	.07	6.6–8.4	None.
Sand	SP	A-3	90–100	90–100	0–10	.05	7.4–8.4	None.
Fine sandy loam	ML, SM	A-2, A-4	100	100	20–75	.12	5.6–6.5	Low.
Sandy clay loam	CL, SC	A-4	100	100	40–65	.14	5.6–6.5	Low to moderate.
Sandy loam	SM	A-2, A-4	100	100	20–40	.12	5.6–6.5	Low.
Silty clay loam	CL	A-6	100	100	85–95	.17	5.6–6.0	Moderate.
Hard limestone								
Silty clay loam	CL	A-6	100	100	85–95	.17	5.6–6.0	Moderate.
Clay	CL, CH	A-7	100	100	90–100	.17	6.1–7.3	High.
Silt loam	ML, CL	A-4	100	100	75–98	.14	5.6–6.0	Low.
Clay	CL, MH, CH.	A-7	100	100	90–100	.17	6.1–8.4	High.
Silt loam	ML, CL	A-4	100	100	75–98	.14	5.6–6.0	Low.
Silty clay loam	ML, CL	A-6, A-7	100	100	85–100	.17	5.6–7.3	Moderate.

TABLE 3.—*Estimated properties*

Soils	Hydrologic soil group	Permeability [1]	Depth from surface
			Inches
Vernon (VeC, VsE)	D	Very slow.	0–6 6–60
Waurika (Wa)	D	Very slow.	0–12 12–60
Yahola:			
Fine sandy loam (Ya)	B	Moderately rapid.	0–35 35–60
Loamy fine sand (Yf)	B	Rapid.	0–60

[1] The estimates apply to the least permeable layer.

TABLE 4.—*Engineering*

Soil series and map symbol [1]	Suitability as source of— Topsoil	Suitability as source of— Select grading material	Suitability as source of— Road fill	Soil features affecting— Farm Ponds / Highway location
Albion (NxC) (For interpretations of the Norge soil in this mapping unit, refer to the Norge series.)	Fair	Good	Good when slopes are stabilized.	Features favorable
Bethany (BeA)	Poor to fair: easily eroded on steep slopes.	Poor: unstable when wet.	Poor: moderate to high shrink-swell potential; unstable when wet.	Moderate to high shrink-swell potential; unstable when wet.
Breaks-Alluvial land complex (Bk)	Poor: material mixed and of limited quantity.	Poor: inaccessible; too clayey.	Poor: material limited; unstable when wet.	Broken topography; unstable when wet; highly plastic.
Brewer (Bm)	Poor: too clayey	Unsuitable: highly plastic.	Poor: highly plastic; unstable when wet.	Nearly level slopes; occasional flooding; unstable when wet.
Broken alluvial land (Br)	Fair: easily eroded on steep slopes.	Poor: somewhat inaccessible; unstable when wet.	Poor: low density; difficult to compact.	Broken topography; frequent flooding; unstable when wet.
Carr (Ca)	Fair: somewhat erodible.	Good	Good when confined and slopes are stabilized.	Nearly level to undulating; occasional flooding.
Carwile (CuB) (For interpretations of the Pratt soil in this mapping unit, refer to the Pratt series.)	Poor to a depth of 2 feet: somewhat easily eroded.	Good to a depth of 2 feet.	Poor: clay subsoil is unstable when wet; highly plastic.	Seasonal high water table; seasonally ponded; highly plastic below a depth of 2 feet.

See footnote at end of table.

of the soils—Continued

Classification: USDA texture	Classification: Unified	Classification: AASHO	Percentage passing sieve—No. 4 (4.7 mm.)	Percentage passing sieve—No. 10 (2.0 mm.)	Percentage passing sieve—No. 200 (0.074 mm.)	Available water capacity	Reaction	Shrink-swell potential
						Inches per inch of soil	*pH value*	
Clay loam	CL	A-6	100	100	75–95	0.17	7.4–7.8	Moderate.
Clay	CL, CH	A-7	100	100	90–100	.17	7.4–8.4	High.
Silt loam	ML, CL	A-4	100	100	75–98	.14	5.1–6.5	Low.
Clay	CL, MH, CH.	A-7	100	100	90–100	.17	6.1–8.4	High.
Fine sandy loam	SM	A-2, A-4	100	100	20–40	.12	7.4–8.4	Low.
Loamy fine sand	SM	A-2	100	100	11–30	.07	7.4–8.4	Low.
Loamy fine sand	SM	A-2	100	100	11–30	.07	7.4–8.4	None.

interpretations of soils

Soil features affecting—Continued: Farm ponds—Continued: Reservoir area	Farm ponds—Continued: Embankment	Agricultural drainage	Irrigation	Terraces and diversions	Waterways
High rate of seepage.	High rate of seepage; high fills unstable.	Not needed.	Features favorable; moderate intake rate; moderate permeability.	Features favorable.	Moderately low available water capacity.
Features favorable for dug ponds; few natural sites suitable for impoundment.	Features favorable.	Not needed.	Slow intake rate; cracks when dry.	Long slopes; nearly level.	Nearly level slopes.
Good depth; possible seepage at abutment.	Shallow soils in places; material cracks when dry.	Not needed.	Broken topography; nonarable.	Nonarable soil; broken topography.	Steep slopes; shallow and deep soils.
Features favorable for dug ponds.	Unstable material; highly plastic.	Nearly level to weakly concave topography.	Occasional flooding; alkaline in the root zone.	Nearly level slopes; occasional flooding.	Nearly level slopes; occasional flooding.
Flooding; high seepage.	Flooding; possible seepage.	Frequent flooding; broken topography.	Frequent flooding; broken topography.	Nonarable soil; frequent flooding.	Frequent flooding; broken slopes.
High rate of seepage; flooding.	High rate of seepage; easily eroded.	Not needed.	Occasional flooding.	Level to undulating topography; occasional flooding.	Level to undulating topography; occasional flooding.
Features favorable for dug ponds.	Features favorable for homogenous fills.	Somewhat poor drainage; depressional areas.	Somewhat poor drainage; very slow permeability.	Nearly level to undulating topography; depressional areas.	Nearly level to undulating topography; depressional areas.

TABLE 4.—*Engineering*

Soil series and map symbol [1]	Suitability as source of— Topsoil	Select grading material	Road fill	Soil features affecting— Farm Ponds / Highway location
Dale (Dc, Ds)	Good	Unsuitable: clay loam too clayey; silt loam unstable when wet.	Poor: unstable when wet.	Nearly level; seldom flooded; weak foundation.
Dougherty (DxB, DxC) (For interpretations of the Eufaula soils in these mapping units, refer to the Eufaula series.)	Poor: low fertility; erodible.	Good	Good when entire profile is used: side slopes may need to be stabilized.	Unstable slopes
Eroded clayey land (Es)	Poor: too shallow and clayey.	Unsuitable: too clayey.	Poor: high shrink-swell potential; unstable when wet.	Some strong slopes; highly plastic; parent material close to surface.
Eroded loamy land (Et)	Good: low fertility	Unsuitable: clay loam areas slightly plastic.	Poor: unstable when wet.	Some strong slopes; material unstable when wet.
Eufaula (DxB, DxC) (For interpretations of the Dougherty soils in these mapping units, refer to the Dougherty series.)	Poor: low fertility; easily eroded.	Poor: unless mixed with binder.	Good when confined and slopes are stabilized.	Unstable slopes
Humbarger (Hu)	Good to fair: easily eroded on steep slopes.	Poor: unstable when wet; somewhat elastic.	Fair to poor: low density; difficult to compact.	Occasional flooding; unstable when wet; weak foundation.
Kaw (Ka, Kc)	Good	Poor: too clayey; unstable when wet.	Fair to poor: high capillary action; unstable when wet; difficult to compact.	Occasional to frequent flooding; unstable when wet; fairly weak foundation.
Kirkland (KnB, KrC2, RkC) (For interpretations of the Renfrow soil in mapping units KrC2 and RkC, refer to the Renfrow series.)	Fair to a depth of 1 foot.	Poor: unstable	Poor: highly plastic; high volume change.	Highly plastic subsoil; poor internal drainage.
Labette (LaD)	Good to a depth of 1½ feet.	Unsuitable: unstable; too clayey.	Poor: moderate to high shrink-swell potential; unstable when wet.	Sloping; moderate to high shrink-swell potential; weak foundation.
Labette-Slickspots complex (LbC2)	Poor: suitable material is of limited depth; Slickspots common.	Unsuitable: too clayey.	Poor: high shrink-swell potential; limestone at a depth of about 3 feet.	Poor internal drainage; highly plastic; limestone at a depth of about 3 feet.
Lela (Lc, Le)	Poor: too clayey	Unsuitable: highly plastic material.	Poor: highly plastic; high volume change; unstable when wet.	Occasional flooding; highly plastic; nearly level to depressional.
Lincoln (Lm)	Unsuitable: too coarse textured.	Good	Good when confined and slopes are stabilized.	Level to undulating topography; frequent flooding.
Loamy broken land (Lo)	Good	Poor: unstable when wet; elastic.	Poor: low density; difficult to compact; fast capillary action.	Steep, broken topography; unstable.

See footnote at end of table.

interpretations of soils—Continued

Soil features affecting—Continued					
Farm ponds—Continued		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment				
Features favorable for dug ponds.	Features favorable	Not needed	Occasional flooding	Nearly level slopes; seldom subject to flooding.	Nearly level slopes; seldom flooded.
High rate of seepage	Fair if entire profile used for homogenous fill.	Not needed	Susceptible to wind erosion; undulating topography.	Undulating and hummocky topography; subject to wind erosion.	Droughty soils; subject to wind erosion.
Limited depth to shale.	Limited borrow material.	Not needed	Nonarable; severely eroded.	Nonarable; severely eroded.	Vegetation hard to establish; Slickspots common; little topsoil.
Features favorable	Features favorable	Not needed	Erosion severe; nonarable.	Nonarable; severely eroded.	Vegetation easily established.
High rate of seepage	Erodible soil; high rate of seepage.	Rapid internal drainage.	Subject to wind erosion; high intake rate.	Undulating and hummocky topography; subject to wind erosion.	Droughty soils; subject to wind erosion.
Features favorable for dug ponds.	Features favorable	Occasional flooding	Occasional flooding	Nearly level slopes; occasional flooding.	Nearly level slopes; occasional flooding.
Features favorable for dug ponds.	Features favorable for low embankment.	Occasional flooding	Occasional flooding	Nearly level slopes; occasional flooding.	Nearly level slopes; occasional flooding.
Features favorable	Low stability; high shrink-swell potential.	Not needed	Very slow permeability; very slow intake rate.	Features favorable	Features favorable.
Sloping	Fair stability; cracks when dry.	Not needed	Sloping	Sloping	Sloping.
Limestone at a depth of about 3 feet.	Low stability; high shrink-swell potential.	Not needed	Numerous Slickspots; high content of sodium.	Eroded soils; Slickspots are unstable; outlets difficult to locate.	Eroded soils; Slickspots are unstable.
Features favorable for dug ponds; flooding.	Low stability; subject to severe cracking; droughty.	Somewhat poor drainage; flooding; very slow internal drainage.	Very slow intake rate; very slow internal drainage; subject to severe cracking.	Level topography; flooding.	Subject to flooding; level topography.
High rate of seepage; flooding.	High rate of seepage.	Frequent flooding	Frequent flooding; low available water capacity; high intake rate.	Nonarable; frequent flooding.	Nonarable; frequent flooding.
Low rate of seepage; steep slopes.	Low rate of seepage; unstable in high fills.	Not needed	Steep, broken topography.	Steep, broken topography.	Steep, broken topography.

TABLE 4.—*Engineering*

Soil series and map symbol [1]	Suitability as source of—			Soil features affecting—
	Topsoil	Select grading material	Road fill	Farm Ponds / Highway location
McLain (MaA, Mb)	Good to fair: silty clay loam is shallow over clay.	Poor: unstable when wet or too clayey.	Poor: unstable when wet; difficult to compact; fast capillary action.	Level topography; seldom flooded; subsoil unstable when wet.
Miller (Mc)	Poor: too clayey	Unsuitable: highly plastic.	Poor to a depth of 2½ feet but good below.	Occasional to frequent flooding; nearly level to depressional.
Newtonia (NeA, NeB, NeC, NnC2)	Good	Poor: unstable when wet.	Poor: close moisture control required; unstable when wet.	Level to gently sloping topography; weak foundation when wet.
Norge (NoA, NoB, NoC, NoC2, NoD, NoD2, NxC). (For interpretations of the Albion soil in mapping unit NxC refer to the Albion series.)	Good	Poor: surface is elastic; shallow over clayey materials.	Poor: unstable when wet.	Level to sloping topography; weak foundation when wet.
Owens (OwE)	Poor: too clayey and shallow.	Unsuitable: highly plastic.	Very poor: high shrink-swell potential; unstable when wet.	Gentle to strong slopes; weak foundation unless shale is close to surface.
Port (Pf, Ps)	Good	Poor: unstable when wet; elastic.	Poor: low density; difficult to compact; high capillary action.	Occasional flooding; weak foundation.
Pratt (PtC, CuB) (For interpretations of Carwile soils in the mapping unit CuB, refer to the Carwile series.)	Poor: low fertility; erodible.	Good	Good when slopes are stabilized.	Cuts easily eroded
Reinach (RcA, RcD)	Good to fair: easily eroded on steep slopes.	Fair: quite elastic	Good to fair: close moisture control required.	Occasional flooding; weak foundation.
Renfrow (RkC, KrC2) (For interpretations of Kirkland soils in the mapping unit KrC2, refer to the Kirkland series.)	Good to a depth of 1 foot.	Poor: unstable and clayey.	Very poor: high volume change; unstable when wet.	Highly plastic subsoil; poor internal drainage; weak foundation.
Sand dunes, Lincoln material (Sa)	Unsuitable: erodible.	Poor unless mixed with binder.	Good when slopes are stabilized.	Unstable slopes
Shellabarger (ShB, ShC, ShD)	Poor: easily eroded	Good	Good	Features favorable
Sogn (SnB, SsF) (For interpretations of Summit soils in the mapping unit SsF, refer to the Summit series.)	Poor: too shallow and too stony.	Unsuitable: too stony and too clayey.	Poor: shallow over bedrock.	Hard limestone at a depth of 9 inches.

See footnote at end of table.

interpretations of soils—Continued

Soil features affecting—Continued					
Farm ponds—Continued		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment				
Features favorable for dug ponds; flooding.	Features favorable.	Not needed.	Features favorable.	Level topography; seldom flooded.	Level topography; seldom subject to flooding.
Features favorable for dug ponds; flooding.	Low stability; subject to cracking.	Somewhat poor drainage; flooding; surface ponding common.	Occasional to frequent flooding; very slow permeability.	Level to depressional topography; subject to flooding.	Subject to flooding; level to depressional topography.
Level to gently sloping topography; features favorable.	Features favorable.	Not needed.	Features favorable.	Features favorable.	Some sloping and eroded areas; other features favorable.
Level to sloping topography; other features favorable.	Features favorable.	Not needed.	Level to sloping topography.	Some sloping areas are eroded; other features favorable.	Some sloping and eroded areas; other features favorable.
Shallow soil; strong slopes.	Limited borrow material; highly plastic.	Not needed.	Strong slopes; very slow internal drainage; shallow.	Shallow soil; very slow internal drainage.	Shallow, droughty soil.
Features favorable for dug ponds.	Features favorable.	Not needed.	Occasional flooding; other features favorable.	Occasional flooding; nearly level slopes.	Occasional flooding; nearly level slopes.
High rate of seepage.	Erodible soil material; unstable.	Not needed.	Rapid intake rate; low available water capacity; subject to wind erosion.	Undulating and hummocky topography; subject to wind erosion.	Droughty; subject to wind erosion.
Features favorable for dug ponds.	Features favorable.	Not needed.	Occasional flooding; other features favorable.	Nearly level slopes.	Nearly level slopes.
Gentle slopes.	Low stability; high shrink-swell potential.	Very slow internal drainage.	Very slow intake rate; very slow internal drainage.	Features favorable.	Features favorable.
High rate of seepage.	Erodible soil material; unstable.	Not needed.	Subject to wind erosion; low water capacity; very rapid intake rate.	Subject to wind erosion; unstable soil; very rapid internal drainage.	Unstable soils; subject to wind erosion; droughty.
Features favorable.	Features favorable.	Not needed.	Features favorable.	Features favorable; subject to some wind erosion.	Features favorable; subject to some wind erosion.
Very shallow to deep soils.	Limited borrow material.	Not needed.	Soils very shallow over limestone.	Soils very shallow over limestone.	Soils very shallow over limestone.

TABLE 4.—*Engineering*

Soil series and map symbol [1]	Suitability as source of—			Soil features affecting—
	Topsoil	Select grading material	Road fill	Farm Ponds / Highway location
Summit (SsF, SuB, SuC, SyC2) (For interpretations of Sogn soils in the mapping unit SsF, refer to the Sogn series.)	Good to a depth of 2 feet.	Unsuitable: plastic.	Very poor: moderate to high shrink-swell potential; limestone is at a depth of about 4 feet in places.	High compressibility; seasonal seepy spots; moderate to high shrink-swell potential.
Tabler (TaA)	Poor	Poor	Very poor: highly plastic; high shrink-swell potential; unstable when wet.	High compressibility; very slow internal drainage; seasonal perched water table; lateral seepage above clay layer.
Vanoss (VaA, VaB, VaC, VaD)	Fair: easily eroded.	Poor: unstable when wet.	Poor: close moisture control required; unstable when wet.	Level to sloping; relatively unstable subsoil.
Vernon (VeC, VsE)	Poor: too clayey and too shallow.	Poor: highly plastic.	Poor: shale or clay substratum close to surface.	Gently sloping to strongly sloping; shale or clay near surface.
Waurika (Wa)	Poor	Very poor: high shrink-swell potential.	Very poor: high shrink-swell potential.	High shrink-swell potential; unstable foundation material.
Yahola (Ya, Yf)	Poor: easily eroded.	Good	Good when slopes are stabilized.	Occasional flooding.

[1] Interpretations were not made for Oil-waste land.

The field moisture equivalent (FME) is the minimum moisture content at which a smooth soil surface will absorb no more water in 30 seconds when the water is added in individual drops. It is the moisture content required to fill all the pores in sands and to approach saturation in cohesive soils. The volume change from field moisture equivalent is the change in volume, expressed as a percentage of the dry volume, that takes place when the moisture content of the soil is reduced from the field moisture equivalent to the shrinkage limit.

Mechanical analyses involves sorting soil components by particle size. All soils can be divided as either coarse grained or fine grained according to the percentage of particles passing the No. 200 sieve. Sand and other granular materials are retained on the No. 200 sieve, but silt and clay materials pass through it. Clay is the fraction passing the No. 200 sieve that is smaller than 0.002 millimeter in diameter. The material between that held on the No. 200 sieve and that having a diameter of 0.002 millimeter is mostly silt.

Liquid limit and plastic limit indicate the effect of water on the consistence of the soil material. As the moisture content of a clayey soil increases from a dry state, the material changes from a semisolid to a plastic state. As the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material passes from a semisolid to a plastic state. The liquid limit is the moisture content at which the material changes from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and plastic limit. It indicates the range of moisture content within which a soil material is plastic.

How Soils are Formed and Classified

This section tells how the factors of soil formation affected the development of soils in Kay County, and it describes some of the processes responsible for the development of horizons. Then the current system of soil classification is explained, and each soil series in the county is placed in classes of this system and in its great soil group in the system adopted in 1938. The soil series, including a profile representative of each series, are described. The last part of this section, based on analytical data, is a general discussion of some properties of the soils in Kay County.

interpretations of soils—Continued

Soil features affecting—Continued						
Farm ponds—Continued		Agricultural drainage	Irrigation	Terraces and diversions	Waterways
Reservoir area	Embankment				
Features favorable	Features favorable	Not needed	Very slow internal drainage; very slow intake rate.	Features favorable	Features favorable.
Features favorable	Unstable material; highly plastic; subject to cracking.	Somewhat poorly drained; very slow internal drainage; seasonal perched water table.	Very slow internal drainage; very slow intake rate.	Nearly level to depressional topography.	Nearly level to depressional topography.
Features favorable	Features favorable	Not needed	Features favorable	Features favorable	Features favorable.
Shallow soils	Limited borrow material.	Not needed	Soils shallow over shale.	Soils shallow over shale.	Shallow, droughty soils.
Features favorable	High fills unstable	Features favorable	Very slow intake rate.	Very slow permeability; nearly level slopes.	Features favorable.
High rate of seepage; flooding.	High seepage	Not needed	Rapid intake rate; subject to flooding.	Level to undulating topography; subject to flooding.	Level to undulating topography; subject to flooding.

Factors of Soil Formation

Soils form a continuum on the land surface. Each soil has a profile, which is a succession of layers, or horizons, in a vertical section. The profile is basic to scientific studies of soil. Most profiles have three master horizons —A, B, and C. The A horizon, commonly called the surface layer, is the uppermost master horizon. The B horizon is commonly called the subsoil, and the C horizon is called the substratum or parent material. All of these master horizons can be subdivided. The subdivisions are identified by a letter plus a number, such as A1, A2, A3, B1, B2, B3. The subdivisions of master horizons provide clues to the processes of soil formation and are important to the use and management of soils.

At a given point, the nature of a profile, including the arrangement of the horizons, depends mainly on the interrelationship of the five factors of soil formation. These factors are (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and existed since accumulation; (3) the plant and animal life on and in the soil; (4) the relief, or lay of the land; and (5) the length of time the forces of soil development have acted on the parent material. All these factors are important, but in different locations and under different conditions, some factors influence the formation of soils more than others.

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The five factors are interdependent; each modifies the effect of the others. Climate and vegetation are the active forces that change the parent material and gradually form a soil. Relief, mainly through its control of runoff, influences the effects of climate and vegetation.

Parent material

In this county the parent material of soils was derived mainly from materials of early Permian, of Quaternary, and of Recent ages. The parent material is older in the eastern part of the county and was derived from hard, partly fractured limestone interbedded with calcareous reddish to grayish shale and clay. These beds of limestone are hard, thick, and moderately resistant to weathering. Slow weathering of limestone is evidenced by the small mesalike areas that rise above the surrounding landscape and are capped with limestone. The very shallow Sogn soils formed where the decomposition of limestone has been very slow. In the parent material of the Labette,

TABLE 5.—*Engineering*

[Tests performed by the Oklahoma Department of Highways in accordance with stand-

Soil name and location	Parent material	Oklahoma report No.	Depth	Horizon	Shrinkage Limit	Shrinkage Ratio	Volume change from field moisture equivalent
			Inches				*Percent*
Brewer silty clay loam: 1,000 feet S. and 200 feet E. of NW. corner, sec. 32, T. 28 N., R. 1 W. (modal).	Alluvium.	SO-6920	0–8	A1	15	1.82	26
		SO-6921	8–22	B2t	10	2.02	55
		SO-6922	36–46	C	12	1.91	50
Kirkland silt loam: 1,320 feet W. and 200 feet S. of NE. corner, sec. 10, T. 28 N., R. 2 W. (modal).	Clays and shales of the Wellington formation.	SO-6917	0–9	Ap	17	1.77	28
		SO-6918	9–22	B2t	11	2.00	76
		[4] SO-6919	30–36	B23	11	2.01	69
Pratt loamy fine sand: 1,600 feet W. of SE. corner, sec. 21, T. 26 N., R. 2 W. (modal).	Eolian deposits.	SO-6923	0–11	A1	[5] NP	NP	NP
		SO-6924	11–40	B2	NP	NP	NP
Shellabarger fine sandy loam: 500 feet E. of SW. corner, sec. 27, T. 27 N., R. 4 E. (modal).	Alluvium from high terraces.	SO-6931	0–8	A1	21	1.62	11
		SO-6932	16–28	B21	14	1.88	25
		SO-6933	42–60	C	14	1.86	12
Tabler silt loam: 250 feet S. and 150 feet E. of NW. corner, SW¼ sec. 2, T. 27 N., R. 2 W. (modal).	Redbeds.	SO-6914	0–8	Ap	18	1.74	13
		SO-6915	8–27	B2t	9	2.05	81
		SO-6916	38–46	C	10	2.01	67
Vanoss silt loam: 1,900 feet W. and 100 feet N. of SE. corner, sec. 22, T. 28 N., R. 3 E. (modal).	Alluvium.	SO-6928	0–12	A1	20	1.74	11
		SO-6929	16–24	B21t	15	1.87	55
		SO-6930	38–54	C	16	1.81	37
Waurika silt loam: 900 feet S. and 200 feet W. of NE. corner, sec. 5, T. 25 N., R. 1 E. (modal).	Alluvium from high terraces.	SO-6925	0–9	Ap	20	1.74	5
		SO-6926	9–26	B21t	8	2.07	86
		SO-6927	38–48	C	9	2.06	57

[1] Mechanical analyses according to the AASHO Designation: T 88–57 (*1*). Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses data used in this table are not suitable for use in naming textural classes for soils.

[2] The Oklahoma Department of Highways classification procedure further subdivides the AASHO A–2–4 subgroup into the following:

Newtonia (fig. 24), and Summit soils, the high content of lime has directly influenced the formation of a strong granular structure.

The central and western parts of the county are underlain by alternating strata of dark-colored shale and clay of the Wellington formation (fig. 25). In the more nearly level areas, this formation is overlain by an old alluvial outwash plain of Pleistocene age. On part of this plain is the parent material of the Tabler, Bethany, and Kirkland soils. Outwash rocks of rounded quartz, 3 to 5 inches in diameter, occur on the level areas of Tabler soils. In many level areas strata of sand and gravel occur at a depth of 15 to 35 feet. Possibly, a thin mantle of loess contributed in the forming of the fairly thick A horizon of the Tabler, Bethany, and Kirkland soils.

From many of the more sloping areas, the alluvial plain has been removed by geological erosion, and Kirkland soils have developed in residuum from the Wellington or Garber formations. The shallow Owens clay developed where the Wellington formation lies near the surface.

The Garber formation has influenced development of soils in the southwestern part of the county. In this formation the clay and shale are redder than those of the Wellington formation. Reddish parent material was derived from the Garber formation and has given rise to Vernon and Renfrow soils. The Vernon soils formed where the parent material is near the surface, and the Renfrow soils formed where it is at a greater depth.

Norge and Vanoss soils developed in loamy sediments that were laid down by rivers and smaller streams. The Norge soils developed on uplands near the Chikaskia River and other streams in thick deposits of clay loam to silty clay loam. These deposits were laid down by the river and other streams when they were flowing at higher elevations. Small water-worn pebbles of quartz are common throughout the profile of Norge soils. In many places coarse sand and gravel occur where the alluvial mantle is in direct contact with the underlying Permian

test data

ard procedures of the American Association of State Highway Officials (AASHO) (*1*)]

Mechanical analysis [1]						Liquid limit	Plasticity index	Classification	
Percentage passing sieve—			Percentage smaller than—						
No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.005 mm.	0.002 mm.			AASHO [2]	Unified [3]
----------	100	97	92	34	28	33	12	A-6(9)	CL.
----------	100	96	88	50	44	49	24	A-7-6(15)	CL.
----------	100	98	86	42	40	50	27	A-7-6(17)	CL.
----------	100	98	87	31	26	34	10	A-4(8)	ML-CL.
----------	100	98	92	47	43	56	27	A-7-6(18)	MH-CH.
99	98	97	90	46	42	57	32	A-7-6(19)	CH.
100	92	18	13	7	6	NP	NP	A-2-3(0)	SM.
100	92	16	12	10	9	NP	NP	A-2-3(0)	SM.
100	99	71	56	16	11	31	6	A-4(7)	ML.
100	98	64	57	25	21	29	10	A-4(6)	CL.
100	96	39	30	17	15	20	3	A-4(1)	SM.
----------	100	97	89	25	21	27	5	A-4(8)	ML-CL.
----------	100	98	95	53	48	63	33	A-7-5(20)	MH-CH
100	99	96	89	45	40	50	25	A-7 6(17)	CL.
----------	100	96	87	26	21	28	5	A-4(8)	ML-CL.
----------	100	99	95	42	35	48	20	A-7-6(14)	ML-CL.
----------	100	97	91	34	29	40	16	A-7-6(10)	ML-CL.
100	99	95	89	25	18	25	4	A-4(8)	ML-CL.
----------	100	98	93	55	50	66	35	A-7-5(20)	MH-CH.
100	99	96	91	45	38	49	26	A-7-6(16)	CL.

A-2-3(0) if the plasticity index equals nonplastic (NP); A-2(0) if the plasticity index equals nonplastic to 5; and A-2-4(0) if the plasticity index is 5 to 10.

[3] The Soil Conservation Service and the Bureau of Public Roads have agreed that all soils having a plasticity index within two points of the A-line are to be given a borderline classification. Examples of borderline classifications thus obtained are ML-CL and MH-CH.

[4] 100 percent of the material in this sample passed the No. 4 sieve (4.7 mm.).

[5] NP=nonplastic.

material. The Albion soils formed on slopes where the coarse sand and gravel lie close to the surface. The Vanoss soils developed in old, alluvial sediments along the Arkansas and Salt Fork Arkansas Rivers. The loamy parent material of both the Norge and the Vanoss soils is fairly high in weatherable minerals and is partly responsible for the permeability and fertility of those soils.

Dougherty, Eufaula, Pratt, and Shellabarger soils formed in sandy materials that were deposited by wind or water and then reworked by wind. These soils are mainly along uplands of the Salt Fork Arkansas and Arkansas Rivers. In an area about 5 miles west of Tonkawa, the parent material is a mixture of eolian loamy fine sand and alluvial clay that have been deposited over the older Wellington formation. Carwile soils developed from the clay, and Pratt soils developed from the loamy fine sand.

The alluvial soils of this and other counties are young and have characteristics that are essentially the same as those of their parent material. In Kay County the Yahola and Carr soils are of this kind because they are on first bottoms and are frequently flooded. Differences in color and texture between the Yahola and Carr soils reflect the differences in the sources of their parent material. The parent material of Yahola soils came from the Permian redbeds and was carried by the Salt Fork Arkansas River. It is reddish-brown fine sandy loam. The parent material of the Carr soils originated in the Rocky Mountains and was carried by the Arkansas River. It is dark grayish-brown, coarser textured fine sandy loam. The Carr and Yahola soils are calcareous because, in the frequent floods, they receive fresh soil material that is high in bases.

Climate

Climate is important in the formation of soils because it has much to do with weathering of parent material, the kind and amount of vegetative cover, and the animal life in and on the soil. Precipitation, as well as alter-

Figure 24.—**Limestone parent material of the Newtonia and other soils in the eastern part of the county.**

nate freezing and thawing, influences the rate at which unweathered clay, shale, or limestone breaks down to form soils. By affecting the kind and amount of vegetation and the rate of biological activity, temperature and moisture indirectly influence the rate that organic matter decays. Temperature also affects the speed of chemical reaction.

Kay County is characterized by a subhumid climate that is generally uniform throughout. Summers are warm, and winters are mild. Most of the moisture falls during the warm months when the temperature favors chemical and biological activity. Variations in temperature cause freezing and thawing and favor the formation of good granular structure, which is a characteristic of most soils in the county. By affecting plant and animal life, an active factor in the formation of soils, climate indirectly affects the kinds of soils that develop.

Precipitation has not been enough in most of Kay County to leach from the soils much of their plant nutrients or generally much of the lime. Most mature soils have a slightly acid surface layer and an alkaline subsoil. In many soils a zone of lime indicates the average depth to which water percolates. This zone may be near the surface in sloping or shallow soils or at a depth of 30 to 40 inches in nearly level soils of the uplands that have a clay subsoil. Most soils that have a loamy subsoil do not have a zone of free lime.

The frequent hard rains in the county have eroded the surface layer of cultivated fields in the uplands and have also caused flooding that deposits fresh silty and clayey alluvium on the flood plains. The loss of material from the surface layer decreases fertility, reduces infiltration, and in places, changes the texture. Because strong winds blow across the county in summer, moisture rapidly evaporates and fine particles are blown from the surface of unprotected areas. This loss of fine particles reduces the fertility of the soils.

Climate has a direct effect on the formation of soils, but in Kay County it has had little effect in the formation of soils of different kinds. Except in local areas, the climate is uniform throughout the county, and the formation of different kinds of soils has been the result of the other four factors of soil formation.

Vegetation and living organisms

Plants, micro-organisms, earthworms, animals, and other forms of life on or in the soils are active in the formation of the soils. Living organisms help to decompose plant residue and to convert nutrients into a form that is more readily available to plants. Living organisms also affect soil development by speeding up or slowing down chemical changes in the soils.

The native vegetation in Kay County consists mainly of prairie grasses, but there are a few small areas of trees in the uplands and along streams. The soils formed under prairie grasses have a dark-colored, friable, granular surface layer that holds moisture and plant nutrients well because the grasses, including their roots, contribute a large amount of organic matter to the soils. In addition, the fibrous roots of the grasses penetrate to a depth of 18 to 24 inches, and some of the smaller roots go much deeper. These roots absorb much of the rain that falls during the growing season and, therefore, lessen the leaching of plant nutrients. Also, the roots of the grasses

Figure 25.—**Alternating beds of clay and shale from the redbeds of the Wellington formation. Soils in the western part of the county formed in this material.**

bring nutrients, mainly calcium, to the surface. These nutrients are returned to the surface layer in the organic residue of plants.

The soils of the uplands that formed under a cover consisting mostly of post oak and blackjack oak are less fertile than the dark-colored, granular soils that formed under grasses. Although a large amount of leaves fall from the trees, much of this organic material is oxidized under the warm climate and is not returned to the soils in an organic form. As the leaves decompose, a weak acid forms and is carried downward by water. In the Dougherty and Eufaula soils, for example, the weakly acid water percolates rapidly and leaches the basic elements, such as calcium and magnesium, from the upper part of the profile. Forming at the same time in the lower part of the profile is sandy clay loam to loamy sand that is colored by traces of iron oxides. These layers retain moisture and plant nutrients in proportion to their content of clay.

The soils formed under bottom-land hardwoods contain more organic matter than those formed under upland oaks. In addition to the organic matter from the trees, these soils received organic matter in the fresh alluvial deposits. Most of these soils are darkened by organic matter to a depth of 10 to 20 inches or more.

Under continuous cultivation some soils lose their favorable granular structure. Grain, hay, and other crops take mineral plant nutrients from the soils, and these nutrients are lost where the crops are harvested. If plowing is at the same depth year after year, plowpans form in some soils and restrict the downward movement of water. This decrease in water below the plowpan lessens the biological and chemical action in the soils and the amount of water available to plants.

Relief

Relief influences the formation of soils through its effect on drainage, erosion, soil temperature, and plant cover. In Kay County relief is largely determined by the degree that underlying bedrock resists weathering and geological erosion. The relief of Kay County is relatively uniform in elevation in the uplands of the central and western parts. The eastern part of the county is characterized by broad gently sloping plains that are strongly dissected by sloping drains. Limestone escarpments in steep narrow bands commonly have differences in elevation of 50 to 100 feet.

Soils have a grayish clay subsoil in upland areas that are nearly flat or depressional and from which there is little if any runoff. Where there is more runoff, the soils are less grayish and generally contain less hydrogen ions in the surface layer. Where runoff is excessive, little water enters the soil, plants do not grow vigorously, and soil formation proceeds slowly. Unless the plant cover is protective, geological or accelerated erosion may progress faster than soil development. Soils on steep slopes have a lime zone at or near the surface because less lime has been leached and soil forms more slowly than on milder slopes.

Wide alluvial bottom lands occur along the Chikaskia and Salt Fork Arkansas Rivers. In areas that are seldom flooded, the slightly higher soils near the river channels are normally more loamy than are the more clayey depressional soils adjoining uplands. Because of the steep limestone escarpment, the flood plain of the Arkansas River is rather narrow in places and is flooded frequently. Soils in these frequently flooded areas vary in texture.

Time

Time as a factor in soil formation cannot be measured strictly in years. The length of time necessary for a soil to develop depends upon the other factors of soil formation. If the other factors have not operated long enough for definite genetic horizons to form, the soil is considered young, or immature. Mature soils have approached equilibrium with their environment and tend to have well-defined horizons.

Most of the soils in Kay County have well-defined horizons and are mature. Examples are Tabler, Bethany, and Kirkland soils of the uplands. Vanoss and Norge are younger, though they have well-expressed horizons. Vernon, Owens, and Sogn soils have been developing a long time, but their horizons are not so well expressed, because their parent material is resistant and because geological erosion has washed away the soil material almost as fast as it formed. Alluvial soils on the bottom lands have been developing for a short time and show little horizon development.

Processes of Horizon Differentiation

Horizon differentiation, or the development of horizons, in a soil profile is the result of the factors of soil formation interacting. In almost all the soils in this county, and elsewhere, processes that have encouraged the development of horizons are (1) accumulation of organic matter, (2) translocation of silicate clay minerals, (3) leaching and accumulation of carbonates, and (4) reduction or transfer of sesquioxides. Other processes, such as geologic erosion and mixing of soil material by burrowing animals, retard the development of horizons. The kinds and number of horizons that form in the soil profile depend on relative effects of the processes that encourage horizon differentiation and those that retard it.

Accumulation of organic matter

The accumulation of organic matter in soils depends mostly on the rate it is added and the rate it decays. After a long period of time in many soils the gain and loss of organic matter tend to be about equal. Even though additions continue, the quantity of organic matter stabilizes and remains fairly constant. Some of the organic matter accumulated in the surface layer is carried downward into the subsoil by earthworms and burrowing animals.

Grass vegetation favors the accumulation of organic matter. In Kay County the content of organic matter in the surface layer of the soils formed under grass stabilizes at 3 percent. But the content of organic matter in all kinds of soils tends to decrease if the soils are cultivated continuously.

The soils formed under a savannah type of vegetation have accumulated less organic matter in the surface layer than the soils formed under a cover that is entirely grass. In soils of this county formed under savannah vegetation, the content of organic matter decreases sharply below a depth of 6 inches. Organic matter in the form

of humus has been transferred, in suspension and solution, from the surface layer to the lower horizons. The Dougherty and Eufaula soils are examples of soils that have an illuviated A2 horizon from which organic matter has been leached.

Translocation of silicate clays

Distinct horizons form in some soils as a result of the translocation of silicate clays from the upper part of the profile to the lower part. This downward translocation is indicated by the presence of clay coatings and films on the ped surfaces in the B horizon.

The clayey B horizon that formed in the Tabler, Kirkland, Renfrow, and Bethany soils is partly the result of the transfer of silicate clays. Vanoss, Norge, Newtonia, and Shellabarger soils have more silicate clays in the B horizon than in the A horizon. Apparently, however, these soils have had less translocation of the clays than the Tabler and Kirkland soils, which have a more clayey B horizon and more abundant clay films. In the Dougherty and Eufaula soils, a distinct A2 horizon that is very low in silicate clays has formed as a result of the translocation of silicate clays. The Pratt soils lack an A2 horizon, but there are small bands of silicate clays in the subsoil that appear to be the result of translocation.

Leaching and accumulation of carbonates

In some soils of the county, calcium has been leached downward to the depth that water generally percolates, generally between 20 and 40 inches, where it accumulates as concretions of calcium carbonate. Among the soils in Kay County showing such accumulation are those of the Tabler, Kirkland, Renfrow, and Carwile series. Calcium has not accumulated in the profile of Norge, Vanoss, Shellabarger, Pratt, Newtonia, and other soils, nor has a distinct illuviated A2 horizon formed. Dougherty and Eufaula soils, however, have a distinct illuviated A2 horizon from which calcium has been leached downward to lower horizons or has been leached completely from the soil profile.

Young alluvial soils that are frequently or even occasionally flooded have a calcareous to alkaline soil profile because it is recharged with bases during each flood. Soils of this kind that are high in calcium are in the Miller, Yahola, Lincoln, Carr, and Humbarger series. The lower part of the Vernon and Owens soils is high in calcium carbonates, but the calcium is from the parent material and is not a result of leaching.

Reduction and transfer of sesquioxides

The movement of sesquioxides from one horizon to another, or locally within a horizon, is common in the soils of Kay County. This movement is indicated in the Summit, Newtonia, and Labette soils by round, black, shotlike concretions that have accumulated in the lower part of the B horizon and in the C horizon. These concretions are 1/8 to 1/4 inch in diameter. In some local areas, concretions of this kind are also in the profile of the Brewer, Bethany, Kirkland, and Lela soils. In the lower part of the poorly drained Carwile soils, the yellowish and grayish mottles are the result of reduction and transfer of iron. In many places the transfer of iron is indicated in the Eufaula and Dougherty soils by the irregular bands of yellowish to reddish mottles that occur in the lower part of the profile.

Processes retarding horizon differentiation

Among the processes that retard the development of distinct horizons are mixing of soil material by earthworms, shrinking and cracking of the soil, growth and decay of plants, accelerated or geologic erosion, and deposition of alluvium.

Earthworms transfer organic matter downward and mix it with the mineral particles of the soil. This transfer downward tends to make the horizon boundaries less distinct, and the mixing of organic matter and mineral particles promotes the formation of clear or gradual boundaries rather than of abrupt ones. The clear or gradual boundaries in the profile of Newtonia, Summit, and Labette soils, as well as the strong granular structure in the A horizon, indicate a large amount of mixing by earthworms.

Horizon boundaries are also modified when soil material moves down into the subsoil through shrinkage cracks. In some soils these cracks develop in the surface layer and the upper part of the clayey B horizon during extremely dry periods. When a heavy rain follows a dry period, the soil material is washed downward in the cracks. The Tabler soils are an example of soils that shrink and crack.

Grasses and other deep-rooted plants also transfer material from one part of the profile to another. Through their roots, these plants absorb nutrients from the lower horizons and, when the plants die, leave them in the upper horizon or on the surface.

In shallow sloping soils, the formation of horizons is hampered by geologic and accelerated erosion, which may remove the soil material as fast as it forms. The Lincoln and other soils on flood plains show little horizon differentiation because they are frequently flooded and constantly receive fresh alluvium.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationships to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First, through classification and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

Thus, in classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and applied in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. They are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*2*) and later revised (*5*). The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. The current system is under continual study (*4, 7*). Therefore, read-

ers interested in developments of this system should search for the latest literature available. In this subsection some of the classes in the current system and the great soil groups of the older system are given for each soil series in table 6. The classes in the current system are briefly defined in the following paragraphs.

ORDER: Ten soil orders are recognized in the current system. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate the soil orders are those that tend to give broad climatic groupings of soils. Two exceptions, Entisols and Histosols, occur in many different climates.

Table 6 shows the five soil orders in Kay County—Entisols, Inceptisols, Mollisols, Alfisols, and Vertisols. Entisols are recent mineral soils that do not have genetic horizons or have only the beginnings of such horizons. Because Inceptisols generally form on young but not recent land surfaces their name is derived from the Latin *inceptum*, for beginning. Mollisols have surface layers darkened by organic matter. Alfisols have argillic horizons with more than 35 percent base saturation. Vertisols are mineral soils that have 30 percent more clay below a depth of 18 centimeters than above that depth and do not have a lithic or paralithic contact within 50 centimeters of the surface.

SUBORDER: Each order is subdivided into suborders, primarily on the basis of those soil characteristics that seem to produce classes having the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders mainly reflect either the presence or absence of waterlogging or soil differences resulting from the climate or vegetation.

GREAT GROUP: Soil suborders are separated into great groups on basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated or those that have pans interfering with growth of roots or movement of water. The features used are the self mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown separately in table 6, because it is the last word in the name of the subgroup.

TABLE 6.—*Soil series classified according to current and old systems* [1] *of classification*

Series	Current classification			Old classification
	Family	Subgroup	Order	Great soil group
Albion	Fine loamy over sandy skeletal, mixed, thermic.	Udic Argiustolls	Mollisols	Reddish Prairie soils.
Bethany	Fine, mixed, thermic	Udic Paleustolls	Mollisols	Reddish Prairie soils.
Brewer	Fine, mixed, thermic	Udic Argiustolls	Mollisols	Brunizems.
Carr	Coarse loamy, mixed, calcareous, mesic.	Typic Udifluvents	Entisols	Alluvial soils.
Carwile	Fine, mixed, noncalcareous, thermic.	Typic Argiaquolls	Mollisols	Planosols.
Dale	Fine silty, mixed, thermic	Udic Haplustolls	Mollisols	Alluvial soils.
Dougherty	Loamy, siliceous, thermic	Arenic Ultic Paleustalfs	Alfisols	Red-Yellow Podzolic soils.
Eufaula	Sandy, siliceous, thermic	Psammentic Ultic Haplustalfs	Alfisols	Red-Yellow Podzolic soils.
Humbarger	Fine loamy, mixed, mesic	Fluventic Haplustolls	Mollisols	Alluvial soils.
Kaw	Fine silty, mixed, thermic	Fluventic Hapludolls	Mollisols	Alluvial soils.
Kirkland	Fine, mixed, thermic	Abruptic Paleustolls	Mollisols	Reddish Prairie soils.
Labette	Fine, mixed, mesic	Udic Argiustolls	Mollisols	Reddish Prairie soils.
Lela	Fine, mixed, thermic	Typic Chromuderts	Vertisols	Alluvial soils.
Lincoln [2]	Mixed, nonacid, thermic	Typic Ustipsamments	Entisols	Alluvial soils.
McLain	Fine, mixed, thermic	Udic Argiustolls	Mollisols	Alluvial soils.
Miller	Fine, mixed, thermic	Udertic Haplustolls	Mollisols	Alluvial soils.
Newtonia	Fine silty, mixed, thermic	Typic Paleudolls	Mollisols	Reddish Prairie soils.
Norge	Fine silty, mixed, thermic	Udic Paleustolls	Mollisols	Reddish Prairie soils.
Owens	Clayey, mixed, thermic, shallow	Typic Ustochrepts	Inceptisols	Lithosols.
Port	Fine silty, mixed, thermic	Fluventic Haplustolls	Mollisols	Alluvial soils.
Pratt	Sandy, siliceous, thermic	Udic Haplustalfs	Alfisols	Chestnut soils.
Reinach	Coarse silty, mixed, thermic	Udic Haplustolls	Mollisols	Alluvial soils.
Renfrow	Fine, mixed, thermic	Vertic Paleustolls	Mollisols	Reddish Prairie soils.
Shellabarger	Fine loamy, mixed, thermic	Udic Argiustolls	Mollisols	Reddish Prairie soils.
Sogn	Fine loamy, mixed, mesic	Lithic Hapludolls	Mollisols	Lithosols.
Summit	Fine, mixed, thermic	Vertic Argiudolls	Mollisols	Brunizems.
Tabler	Fine, mixed, thermic	Abruptic Paleustolls	Mollisols	Chernozems.
Vanoss	Fine silty, mixed, thermic	Udic Argiustolls	Mollisols	Reddish Prairie soils.
Vernon	Clayey, mixed, thermic, shallow	Typic Ustochrepts	Inceptisols	Lithosols.
Waurika	Fine, mixed, thermic	Abruptic Paleustolls	Alfisols	Planosols.
Yahola	Coarse loamy, mixed, calcareous, thermic.	Typic Ustifluvents	Entisols	Alluvial soils.

[1] Placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

[2] In later surveys, the soils in this series have been placed in the Crevasse series.

SUBGROUP: Great groups are subdivided into subgroups, one representing the central (typic) segment of the group and others, called intergrades, that have properties of one great group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjective before the name of the great group. An example is Vertic Paleustolls.

FAMILY: Families are separated within a subgroup primarily on the basis of properties important to the growth of plans or behavior of soils where used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness or horizons, and consistence. An example is the fine, mixed, thermic family of Vertic Paleustolls.

Descriptions of the Soil Series

In this subsection the soil series represented in Kay County, including a profile typical of the series, are described in alphabetic order. For a description of each soil mapped in the county, as well as additional information about the series, refer to the section "Descriptions of the Soils," near the beginning of this soil survey.

ALBION SERIES

The Albion series consists of loamy to sandy soils that developed in beds of unconsolidated gravelly material. These soils occupy sloping uplands near flowing streams or rivers.

The Albion soils have a more sandy profile than the associated Norge soils and contain a large amount of gravel in the substratum, which the Pratt and Shellabarger soils lack.

Profile of Albion sandy loam in a cultivated field (850 feet west and 75 feet north of southeast corner of southwest quarter of sec. 36, T. 27 N., R. 1 W.):

Ap—0 to 8 inches, brown (7.5YR 4/2) sandy loam, dark brown (7.5YR 3/2) when moist; weak, fine, granular structure to structureless; friable when moist, slightly hard when dry; numerous roots; few small quartz pebbles on the surface; pH 5.6; abrupt boundary.

B1—8 to 13 inches, reddish-brown (5YR 4/4) heavy fine sandy loam, dark reddish brown (5YR 3/4) when moist; weak, fine and medium, granular structure; friable when moist; hard when dry; numerous roots and pinholes; pH 5.6; clear boundary.

B2t—13 to 26 inches, reddish-brown (5YR 4/4) light sandy clay loam, dark reddish brown (5YR 3/4) when moist; moderate, medium, granular structure; friable when moist, extremely hard when dry; pH 6.0; gradual boundary.

C—26 to 60 inches, yellowish-red (5YR 5/6) coarse sand and gravel, yellowish red (5YR 4/6) when moist; structureless; loose when dry or moist; pH 6.1.

The A horizon of Albion soils ranges from loamy sand to sandy loam or loam but is dominantly sandy loam. The B1 horizon ranges from heavy fine sandy loam to light sandy clay loam. The B2t horizon ranges from brown through reddish brown in a hue 7.5YR or 5YR. It ranges from heavy sandy loam to sandy clay loam in texture. Depth to coarse sand and gravel ranges from about 20 to 40 inches. The content of coarse sand and gravel ranges from 50 to 70 percent in the C horizon. The profile ranges from medium acid to neutral in reaction.

BETHANY SERIES

In the Bethany series are deep, dark-colored soils that developed in alkaline, clayey and silty earths. These soils are on nearly level high terraces and undissected ancient alluvial plains. They have granular, permeable A and B1 horizons that together are more than 14 inches thick over a slowly permeable, clayey B2t horizon.

The Bethany soils are less sloping and are deeper to a B2 horizon than the associated Kirkland soils, which lack a B1 horizon. They are more brownish than the Tabler and Norge soils and, unlike the Tabler soils, have a distinct B1 horizon. The subsoil of Bethany soils is more clayey than that of the Vanoss soils.

Profile of Bethany silt loam in a cultivated field (1,390 feet north and 95 feet east of southwest corner of sec. 3, T. 27 N., R. 2 E):

Ap—0 to 9 inches, dark grayish-brown (10YR 4/2) silt loam, very dark brown (10YR 2/2) when moist; moderate, medium and fine, granular structure; very friable when moist; slightly hard when dry; pH 5.6; abrupt boundary.

B1—9 to 16 inches, brown (10YR 4/3) clay loam, dark brown (10YR 3/3) when moist; weak, fine, subangular blocky structure breaking to moderate, medium and coarse, granular structure; friable when moist, slightly hard when dry; pH 6.0; clear boundary.

B21t—16 to 28 inches, brown (10YR 4/3) light clay, dark brown (10YR 3/3) when moist, slightly browner than B1 horizon; moderate, medium, blocky structure; surface of peds slightly shiny when moist; very firm when moist, very hard when dry; pH 6.6; gradual boundary.

B22t—28 to 37 inches, brown (10YR 4/3) light clay, dark brown (10YR 3/3) when moist; weak, fine, blocky structure; very firm when moist, very hard when dry; few fine concretions of iron; pH 7.0; gradual boundary.

B3—37 to 48 inches, brown (10YR 4/3) heavy silty clay loam, dark brown (7.5YR 3/2) when moist; few, fine, faint mottles of dark yellowish brown and brown; weak, fine, blocky structure; very firm when moist, very hard when dry; pH 7.0; gradual boundary.

B32—48 to 60 inches, brown (7.5YR 4/4) heavy silty clay loam, dark brown (7.5YR 3/2) when moist; common, medium, distinct mottles of yellowish red (5YR 4/6) and light brownish gray (10YR 6/2); weak, fine, blocky structure; firm when moist, very hard when dry; few soft calcium carbonate concretions; pH 8.0.

The A horizon ranges from dark grayish brown to brown in a hue of 10YR or 7.5YR. It is mainly silt loam, but in some areas it is loam. The depth to slowly permeable clay ranges from 14 to 26 inches but averages 16 inches. The B2t horizons range from dark grayish brown to brown in a hue of 10YR or 7.5YR. A B31 horizon occurs in some places and ranges from clay loam to clay. Its color is similar to that of the B2t horizon but faint mottling occurs in some places. The B32 horizon ranges from light clay loam to clay. Reaction is medium acid or slightly acid in the A horizon and is neutral or alkaline in the B horizon. In some places calcium carbonate concretions occur below a depth of 32 inches.

BREWER SERIES

The Brewer series consists of slowly permeable, dark-colored soils of the prairie that occur on terraces along flowing streams. These soils have a clayey subsoil.

The Brewer soils are darker colored and finer textured than the Port soils. In contrast with McLain soils, Brewer soils have horizons with more textural development, are darker to a greater depth, and are deeper to reddish colors. The A1 horizon of Brewer soils is more granular and less clayey than that of Lela soils.

Profile of Brewer silty clay loam in a cultivated field (1,000 feet south and 200 feet east of northwest corner of sec. 32, T. 28 N., R. 1 W.):

Ap—0 to 8 inches, grayish-brown (10YR 5/2) silty clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium, granular structure; friable when moist, slightly hard and hard when dry; numerous roots; pH 5.7; clear boundary.

B2t—8 to 22 inches, dark-gray (10YR 4/1) clay, very dark gray (10YR 3/1) when moist; moderate, coarse and medium, blocky structure; very firm when moist, very hard when dry; very slowly permeable; few, fine, black concretions; dull shine on surfaces of peds; few pinholes and roots; pH 7.3; gradual boundary.

B3—22 to 34 inches, dark grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) when moist; weak, medium, blocky structure to massive; very firm when moist, very hard when dry; very slowly permeable; few, fine, black concretions; pH 8.0; gradual boundary.

C—34 to 46 inches, dark yellowish-brown (10YR 4/4) heavy silty clay loam, dark brown (10YR 3/3) when moist; common, fine, faint mottles of yellowish brown and dark grayish brown; massive; very firm when moist, very hard when dry; few, fine, black concretions; few concretions of calcium carbonate; pH 8.0.

In most places the A horizon is silty clay loam, but in some places it is heavy silt loam. It ranges from 6 to 18 inches in thickness. The A horizon ranges from grayish brown to very dark brown in a hue of 10YR. The B2t and B3 horizons range from heavy clay loam or silty clay to clay. The color of the B2t horizon ranges from dark gray to dark brown. Mottles that are more grayish or brownish than typical occur in some places below a depth of 28 inches. Colors are dominantly in a hue of 10YR throughout the profile, and depth to material redder than 7.5YR hue ranges from 30 to 80 inches in some areas. Reaction ranges from medium acid to slightly acid in the A horizon and is neutral or alkaline in the B and C horizons. Accumulations of calcium carbonate concretions below a depth of 34 inches are common.

CARR SERIES

In the Carr series are well-drained, loamy soils that occur on low terraces of the Arkansas River and are often flooded. These soils consist of only slightly altered, stratified, calcareous alluvium.

The Carr soils, which are similar to the Yahola soils but less reddish, formed in alluvium from material of Tertiary age, whereas the Yahola soils formed in alluvium mainly from Permian redbeds. The Carr soils are less sandy than the Lincoln soils but are more sandy and generally occur closer to the channel of the Arkansas River than the Humbarger soils.

Profile of Carr fine sandy loam in a cultivated field (520 feet north and 60 feet east of southwest corner of sec. 31, T. 28 N., R. 4 E.):

A1—0 to 15 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, granular structure; very friable when moist, soft when dry; calcareous; clear boundary.

AC—15 to 34 inches, grayish-brown (10YR 5/2) fine sandy loam that is weakly stratified with loamy sand and light loam; dark grayish brown (10YR 4/2) when moist; weak, fine, granular structure ranging almost to massive; very friable when moist, soft when dry; calcareous; gradual boundary.

C—34 to 60 inches, pale-brown (10YR 6/3) fine sandy loam, brown (10YR 4/3) when moist; massive; very friable when moist, loose when dry; calcareous.

The A1 horizon is predominantly fine sandy loam but ranges from loamy fine sand to clay loam in local spots. It ranges from pale brown through grayish brown to dark brown in a hue of 10YR. Because sand, silt, and clay are deposited during floods, the texture and color of the A1 horizon may change locally. Higher areas normally are more sandy than lower areas. Beneath the A1 horizon, color ranges from grayish brown or pale brown to yellowish brown. Some stratification with more clayey or sandy material is common in all horizons. In some places the soils are noncalcareous to a depth of about 36 inches.

CARWILE SERIES

The Carwile series is made up of deep, dark-colored soils that have a mottled, compact clay lower subsoil. These soils are nearly level to slightly depressional. They developed in a mantle of Pleistocene sediments that is underlain by material of the Wellington formation.

The Carwile soils are more clayey and more mottled in the B2t horizon than the Shellabarger and Pratt soils. Unlike the Dougherty and Eufaula soils, Carwile soils lack a light-colored A2 horizon and have a mottled B2t horizon.

Profile of Carwile fine sandy loam in a cultivated field 1,320 feet north and 200 feet west of southeast corner of sec. 28, T. 26 N., R. 2 W.):

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) fine sandy loam, dark brown (10YR 3/3) when moist; weak, fine, granular structure; soft when dry, very friable when moist; pH 5.1; abrupt boundary.

B1—7 to 20 inches, dark yellowish-brown (10YR 4/4) light sandy clay loam, dark brown (10YR 3/3) when moist; moderate, medium, granular structure; friable when moist, hard when dry; numerous roots and pores; pH 6.0; clear boundary.

B2t—20 to 28 inches, grayish-brown (10YR 5/2) clay, dark grayish brown (10YR 4/2) when moist; many, medium, distinct mottles of dark yellowish brown (10YR 4/4) and gray (10YR 5/1); weak, medium, blocky structure to massive; very firm when moist, very hard when dry; very slowly permeable; few fine roots; pH 7.0; gradual boundary.

C—28 to 60 inches, light brownish-gray (2.5Y 6/2) clay, grayish brown (2.5Y 5/2) when moist; many, medium and coarse, prominent mottles of yellowish brown (10YR 5/6) and other shades of gray and brown; massive; very hard when dry; many concretions of iron oxide; pH 8.0; calcareous.

The A horizon ranges from dark gray or dark grayish brown to dark brown in a hue of 10YR. Its texture ranges from clay loam to fine sandy loam and is more clayey in the lower depressions. It is 6 to 10 inches thick. The B1 horizon ranges from heavy sandy loam to sandy clay loam and is 4 to 14 inches thick. The B2t horizon is gray or grayish-brown to dark-brown clay that is mottled with various shades of gray, brown, and red in a hue of 2.5Y to 2.5YR. The C horizon is variously shaded with brown and gray and has coarse mottles. Reaction is

strongly acid or medium acid in the A horizon and is neutral in the lower B and C horizons. In some places the lower B and C horizons are calcareous.

DALE SERIES

The Dale series consists of well-drained soils that are on low terraces of the Arkansas River and are seldom flooded. These soils developed in brownish alluvium that contains fairly large amounts of plant nutrients.

The Dale soils are darker than the Port soils and less reddish and less clayey than McLain soils. The subsoil of the Dale soils is less clayey than that of Brewer soils. In contrast with Humbarger soils, Dale soils are at higher positions, are less stratified and noncalcareous, and are flooded less frequently.

Profile of Dale clay loam in a cultivated field (310 feet south and 108 feet east of northwest corner of sec. 17, T. 27 N., R. 4 E.):

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) clay loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium or fine, granular structure; friable when moist; pH 6.5; abrupt boundary.

A1—7 to 17 inches, dark grayish-brown (10YR 4/2) clay loam, very dark brown (10YR 2/2) when moist, slightly darker than the Ap horizon; strong, medium, granular structure; friable when moist, hard when dry; numerous roots and fine pinholes; pH 6.5; gradual boundary.

AC—17 to 23 inches, dark-brown (10YR 3/3) clay loam, very dark brown (10YR 2/2) when moist; crushes to a more brownish color; strong, medium, granular structure; friable when moist, hard when dry; numerous pinholes; pH 6.5; gradual boundary.

C—23 to 60 inches, brown (10YR 4/3) light clay loam, dark brown (10YR 3/3) when moist; moderate, medium, granular structure; friable when moist, hard when dry; numerous single grains of sand on the surfaces of peds.

The A horizon ranges from dark grayish brown to dark brown in a hue of 10YR. It is generally clay loam, but there are small areas of heavy silt loam and silty clay loam. The AC and C horizons range from brown or dark grayish brown to yellowish brown but are mainly dark brown to brown. The texture of these horizons is generally clay loam but ranges to silty clay loam. The AC and C horizons in some places are more sandy as depth increases. In some places the C horizon is stratified with material that is more clayey or more sandy than light clay loam. The A horizon is slightly acid, and the AC and C horizons are slightly acid to mildly alkaline. Dale silt loam contains less clay throughout the profile than the soil described.

DOUGHERTY SERIES

In the Dougherty series are loamy soils on undulating to hummocky old stream terraces along the Arkansas River. These soils developed in slightly acid or medium acid sandy alluvium and eolian deposits under a mixed cover of blackjack and post oaks.

Dougherty soils occur with the Eufaula soils and have a thinner A2 horizon. They have a more developed subsoil than the Eufaula or Pratt soils. The Dougherty soils are more sandy than Shellabarger and have a distinct light-colored A2 horizon.

Profile of Dougherty fine sandy loam under a cover of blackjack and post oaks (385 feet north and 30 feet east of southwest corner of sec. 21, T. 27 N., R. 4 E.):

A1—0 to 5 inches, grayish-brown (10YR 5/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; very weak, fine, granular structure; very friable when moist, soft when dry; pH 6.0; clear boundary.

A2—5 to 22 inches, pale-brown (10YR 6/3) light fine sandy loam, dark yellowish brown (10YR 4/4) when moist; very weak, fine, granular structure to massive; very friable when moist; pH 6.0; clear boundary.

B2t—22 to 32 inches, brown (7.5YR 4/4) sandy clay loam, dark brown (7.5YR 3/4) when moist; weak, medium, blocky structure to massive; firm when moist; very hard when dry; pH 6.0; gradual boundary.

B3—32 to 60 inches, strong-brown (7.5YR 5/6) loamy fine sand, strong brown (7.5YR 4/6) when moist; single grain (structureless); loose when moist or dry; permeable; pH 6.0.

The A1 horizon ranges from fine sandy loam to loamy fine sand but is fine sandy loam in most places. The A1 horizon ranges from grayish brown or brown to pale brown in a hue of 10YR. The A2 horizon is pale brown or light yellowish brown in a hue of 10YR. Its texture ranges from fine sand to loamy fine sand or fine sandy loam.

Depth to the B2t horizon ranges from 20 to 40 inches. The B2t horizon is mainly sandy clay loam but ranges from heavy fine sandy loam to heavy sandy clay loam. The B3 horizon ranges from loamy fine sand to sandy clay loam. Reaction ranges from strongly acid to slightly acid for all horizons.

EUFAULA SERIES

In the Eufaula series are light-colored, acid, deep loose sands. These soils occur near the Arkansas River on old stream terraces that are undulating to hummocky.

Although the Eufaula soils show little clay development, they have a definite A2 horizon, which is lacking in the Pratt soils. Eufaula soils lack the sandy clay loam B horizon within 40 inches of the surface as is typical of Dougherty soils.

Profile of Eufaula fine sand under a cover of blackjack and post oaks (375 feet north and 20 feet east of southwest corner of sec. 21, T. 27 N., R. 4 E.):

A1—0 to 6 inches, grayish-brown (10YR 5/2) fine sand, very dark grayish brown (10YR 3/2) when moist; very weak, fine, granular structure to single grain; very friable when moist, loose when dry; numerous roots; pH 5.5; clear boundary.

A2—6 to 26 inches, pale-brown (10YR 6/3) fine sand, brown (10YR 4/3) when moist; single grain; loose when moist or dry; pH 6.0; clear boundary.

B2t—26 to 60 inches, light yellowish-brown (10YR 6/4) fine sand, yellowish brown (10YR 5/4) when moist; thin irregular bands of yellowish-red (5YR 5/6) sandy loam about 1 inch thick; single grain; loose when moist or dry; permeable; pH 6.0.

The A1 horizon is mainly fine sand but ranges to loamy fine sand. Its color is grayish brown to brown in a hue of 10YR. The A2 horizon ranges from very pale brown to brown in a hue of 10YR. In some places below a depth of 40 inches, there is an illuviated horizon about 1 foot thick. This horizon consists of yellowish-red sandy loam to sandy clay loam. It is underlain by more sandy material. Many areas have thin bands ¼ inch to 2 inches in thickness of sandy loam to sandy clay loam in the lower horizon. Reaction ranges from strongly acid to slightly acid throughout the solum.

HUMBARGER SERIES

The Humbarger series consists of well-drained, calcareous, loamy alluvium on flood plains of the Arkansas River. These soils are subject to occasional flooding that deposits brownish sediments.

The Humbarger soils are less sandy and more loamy than Carr soils and are more loamy than Lincoln soils. In contrast with Dale soils, Humbarger soils are calcareous throughout the profile, are more stratified, and are in lower, more frequently flooded positions. Humbarger soils have a less silty A horizon than Kaw soils.

Profile of Humbarger loam in a cultivated field (900 feet east and 700 feet south of northwest corner of sec. 26, T. 28 N., R. 3 E.):

A1—0 to 14 inches, grayish-brown (10YR 5/2) loam, very dark grayish brown (10YR 3/2) when moist; moderate, medium and fine, granular structure; very friable when moist, slightly hard when dry; open channels and pores; calcareous; gradual boundary.

AC—14 to 31 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; weak, fine, subangular blocky structure; friable when moist, hard when dry; weakly stratified with slightly more clayey material; numerous worm casts and pinholes; calcareous; gradual boundary.

C—31 to 60 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) when moist; weak, fine and medium, granular structure; friable when moist, hard when dry; weakly stratified with clay loam and fine sandy loam; abundant pinholes; calcareous.

The A1 horizon is dominantly loam but ranges from fine sandy loam to clay loam in texture and from grayish brown to dark grayish brown in color. The AC horizon is 10 to 30 inches thick and ranges from light loam to heavy silty clay loam. The color of the AC horizon ranges from grayish brown to dark brown in hues of 10YR and 7.5YR. All horizons contain strata of material that is slightly more sandy or clayey than the matrix. Humbarger soils are commonly calcareous throughout the profile, but in some areas they are mildly alkaline to a depth of about 36 inches.

KAW SERIES

In the Kaw series are moderately well drained, neutral or medium acid, granular soils that developed in silty alluvium along streams throughout the county. The alluvium washed from uplands of shale and limestone.

The Kaw soils are darker colored than the Port soils, less clayey than the Lela soils, and lack the textural B horizon that is typical of Brewer soils.

Profile of Kaw silty clay loam in a cultivated field (170 feet east and 265 feet north of southwest corner of sec. 23, T. 27 N., R. 1 E.):

A1—0 to 24 inches, very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) when moist; moderate, medium, granular structure; friable when moist, hard when dry; pH 6.2; gradual boundary.

AC—24 to 36 inches, very dark grayish-brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) when moist; moderate, medium, granular structure; firm when moist, hard when dry; pH 6.5; gradual boundary.

C—36 to 60 inches, brown (10YR 4/3) silty clay loam, dark brown (10YR 3/3) when moist; weak, medium, granular structure; common, fine, faint mottles of strong brown; firm when moist, hard when dry; pH 6.5.

The A horizon ranges from very dark gray to very dark grayish brown in a hue of 10YR. It is silty clay loam in most places, but there are areas of heavy silt loam and clay loam. The AC horizon is mainly silty clay loam, but it ranges from heavy silty clay loam or heavy silt loam to medium clay loam in texture and from very dark grayish brown or dark brown to dark gray in color. In some areas that adjoin somewhat poorly drained soils, the substratum, below a depth of 30 inches, is mottled with shades that are more brownish and grayish than the matrix. Reaction is medium acid to neutral for all horizons. Throughout the profile, Kaw silt loam is less clayey than Kaw silty clay loam.

KIRKLAND SERIES

The Kirkland series consists of deep, dark-colored, slightly acid soils of the prairie that have an A horizon less than 14 inches thick. These soils developed in alkaline clay of ancient alluvial plains and clay and shale of the Wellington formation.

In contrast with the Bethany soils, the Kirkland soils lack the clay loam B1 horizon between the A and B2t horizons, and are less than 14 inches to the B horizon. Kirkland soils are more brownish than Tabler soils, which have a more grayish A horizon and an abrupt boundary between the A and B horizons. The darker A and B2t horizons of Kirkland soils distinguish them from the more reddish Renfrow soils. The B2t horizon of Kirkland soils is darker and more clayey than that of the Norge soils.

Profile of Kirkland silt loam in a cultivated field (1,400 feet east and 75 feet south of northwest corner of sec. 6, T. 27 N., R. 2 E.):

Ap—0 to 10 inches, dark grayish-brown (10YR 4/2) silt loam, very dark grayish brown (10YR 3/2) when moist; moderate, fine or medium, granular structure; friable when moist, slightly hard when dry; pH 5.6; clear boundary.

B2t—10 to 30 inches, dark-brown (10YR 3/3) clay, very dark brown (10YR 2/2) when moist; moderate, medium, blocky structure; peds are extremely hard when dry; very slowly permeable; many voids; pH 7.0; gradual boundary.

B3—30 to 38 inches, dark-brown (10YR 4/3) clay, dark brown (10YR 3/3) when moist; weak, fine, blocky structure to massive; very firm when moist, extremely hard when dry; very slowly permeable; concretions of calcium carbonate; calcareous; gradual boundary.

B32—38 to 60 inches +, brown (7.5YR 4/4) silty clay, dark brown (7.5YR 3/2) when moist; weak, fine, blocky structure to massive; very firm when moist, extremely hard when dry; few, small, black concretions and many concretions of calcium carbonate.

The A horizon ranges from dark grayish brown to dark brown in a hue of 10YR. Its texture is mainly silt loam in most places but is clay loam in some places. In some areas there is a transitional layer between the A and B2t horizons that is less than 2 inches thick. The depth to the B2t horizon is 14 inches or less and generally is between 8 and 12 inches. The B2t horizon ranges from grayish brown to dark brown in a hue of 10YR or 7.5YR, but the hue is generally 10YR. The B32 horizon ranges from brown to dark reddish brown in a hue of 7.5YR or 5YR. Concretions of calcium carbonate commonly occur at a depth of 32 inches. The lower horizons are faintly mottled in some places. The A horizon is medium acid or slightly acid, and the B horizon is neutral in some places. In other places the B horizon is calcareous.

LABETTE SERIES

The Labette series consists of deep to moderately deep, granular soils that developed in residuum from interbedded limestone and calcareous shale. These soils formed under grasses on sloping colluvial foot slopes below escarpments of Sogn and Summit soils in the eastern part of the county.

Labette soils have a darker, less reddish A horizon than the Newtonia soils and a more clayey B horizon. They are more brownish and have a less clayey B horizon than the Summit soils. The Labette soils are deeper and less grayish than the associated Sogn soils, which are very shallow.

Profile of Labette clay loam in a native pasture (700 feet north and 100 feet east of southwest corner of sec. 10, T. 28 N., R. 4 E.):

A1—0 to 9 inches, dark-brown (10YR 3/3) clay loam, very dark brown (10YR 2/2) when moist; strong, medium and coarse, granular structure; friable when moist, hard when dry; abundant roots; pH 6.8; clear boundary.

A3—9 to 18 inches, brown (7.5YR 4/2) heavy clay loam, dark brown (7.5YR 3/2) when moist; strong, coarse, granular structure; firm when moist, very hard when dry; few organic stains on surfaces of peds; abundant roots; pH 7.0; clear boundary.

B2t—18 to 26 inches, reddish-brown (5YR 4/4) light clay, dark reddish brown (5YR 3/4) when moist; weak, fine, blocky structure; very firm when moist, very hard when dry; few concretions of black shotlike material; pH 7.5; gradual boundary.

B3—26 to 48 inches, reddish-brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) when moist; weak, fine, blocky structure to massive; very firm when moist, very hard when dry; few fine root hairs; few concretions of black shotlike material; numerous concretions of calcium carbonate.

The A horizon ranges from very dark brown to dark brown in a hue of 10YR or 7.5YR. It generally is clay loam but is heavy silt loam in small areas. The B horizon ranges from dark brown to reddish brown or dark reddish brown in a hue of 7.5YR or 5YR. It is clay in most places but is heavy clay loam in small areas. The B horizon ranges from neutral to calcareous. The depth to limestone is 2 to 4 feet or more, except in the more sloping areas directly below limestone escarpments where these soils are shallower than normal and in spots are seepy. The A horizon is slightly acid or neutral.

LELA SERIES

The Lela series consists of somewhat poorly drained soils that developed in calcareous, clayey alluvium.

In contrast with the Miller soils, the Lela soils are darker colored, are more grayish, and are noncalcareous at the surface. Lela soils are more clayey below the Ap horizon than the McLain soils and are darker to a greater depth. They have a more clayey A horizon than Brewer soils and lack a textural B horizon. The Lela soils are more clayey and less granular than the Kaw soils.

Profile of Lela clay in a cultivated field (75 feet east and 100 feet north of southwest corner of southeast quarter of sec. 23, T. 29 N., R. 2 W.):

Ap—0 to 6 inches, dark-gray (10YR 4/1) light clay, black (10YR 2/1) when moist; gray (10YR 5/1) crust one-fourth inch thick on surface; cracks in crust form irregularly shaped spots 2 to 4 inches across; weak, fine and medium, granular structure; very firm when moist, very hard when dry; few fine roots; pH 6.0; abrupt boundary.

A1—6 to 44 inches, very dark gray (10YR 3/1) clay, black (10YR 2/1) when moist; compound moderate, medium, blocky structure to massive, and more massive with depth; peds have shiny surfaces when moist; small uniform sand grains on surfaces of peds; very plastic when moist; very slowly permeable; pH 7.0; gradual boundary.

AC—44 to 53 inches, dark-brown (10YR 3/3) clay, dark brown (10YR 3/3) when moist; massive; very plastic when moist, extremely hard when dry; very slowly permeable; few, small, black, shotlike concretions and small scattered concretions of calcium carbonate; pH 8.0; calcareous; gradual boundary.

C—53 to 60 inches, brown (7.5YR 5/4) clay, dark brown (7.5YR 4/4) when moist; massive; very hard when dry; very slowly permeable; some dark-colored stains and small, black, shotlike concretions; scattered concretions of calcium carbonate; pH 8.0; calcareous.

The A horizons range from dark gray or very dark gray to very dark brown in a hue of 10YR. The depth to dense clay ranges from 4 to 8 inches but averages about 6 inches. The AC horizon ranges from dark gray to dark brown in hues of 10YR and 7.5YR and from 8 to 20 inches in thickness. Reaction ranges from medium acid to neutral in the upper 30 inches and is neutral below 30 inches. In some places the soil material is calcareous below 30 inches. Faint mottles of brown or reddish brown occur in places in the lower horizons. Areas that are covered by a few inches of recent overwash vary more than the typical profile in texture and color of the surface layer.

LINCOLN SERIES[8]

The Lincoln series is made up of grayish-brown to pale-brown, calcareous alluvium that has been altered little since it was laid down, though fresh material is deposited during the recurrent floods. These soils lie on flood plains, mainly along the Arkansas River.

Lincoln soils are less reddish than the Yahola soils and have a sandier AC horizon. Compared with the closely associated Carr soils, the Lincoln soils are more sandy, contain more coarse sand, and are more often flooded.

Profile of Lincoln loamy sand in native grass (820 feet east and 50 feet north of center of sec. 1, T. 26 N., R. 4 E.):

A—0 to 15 inches, grayish-brown (10YR 5/2) loamy sand, very dark grayish brown (10YR 3/2) when moist; structureless; loose when dry or moist; calcareous; clear boundary.

AC—15 to 60 inches, pale-brown (10YR 6/3) stratified sand, loamy sand, and gravel, brown (10YR 5/3) when moist; structureless; loose when dry or moist; calcareous.

The A horizon ranges from fine sand to fine sandy loam in most places, but small areas of clay loam and clay occur. This horizon ranges from grayish brown to pale brown or brown in a hue of 10YR. The AC horizon is loamy fine sand to very coarse sand, and in many places it is stratified and commonly contains thin seams of gravel.

MCLAIN SERIES

The soils in the McLain series developed in reddish, calcareous alluvium on terraces above the ordinary level

[8] In later surveys, the soils in this series have been placed in the Crevasse series.

of the Salt Fork Arkansas River. The sediments in which these soils formed originated mainly from Permian redbeds.

The McLain soils have a more reddish B horizon than Brewer soils and are more clayey than the Port and Reinach soils. McLain soils are less clayey in the A horizon than Lela soils.

Profile of McLain silty clay loam in an alfalfa field (1,000 feet south of northeast corner of sec. 36, T. 25 N., R. 1 W.):

Ap—0 to 8 inches, dark-brown (10YR 3/3) silty clay loam, very dark brown (10YR 2/2) when moist; moderate, medium, granular structure; friable when moist, sticky when wet; numerous roots; pH 6.0; abrupt boundary.

B21t—8 to 21 inches, dark reddish-brown (5YR 3/3) light clay, dark reddish brown (5YR 3/2) when moist; moderate, medium, blocky structure; extremely firm when moist, very hard when dry; few worm casts; pH 6.5; gradual boundary.

B22t—21 to 36 inches, reddish-brown (5YR 4/4) silty clay loam, dark reddish brown (5YR 3/4) when moist; moderate, medium, subangular blocky structure breaking to moderate, medium, granular structure; firm when moist, very hard when dry; some worm casts, roots, and pinholes; pH 7.0; gradual boundary.

C1—36 to 48 inches, yellowish-red (5YR 4/6) silty clay loam, reddish brown (5YR 4/4) when moist; weak, medium, granular structure; friable when moist; numerous pinholes; pH 7.0.

The A horizon is mainly silty clay loam, but it is heavy silt loam in small areas. It ranges from dark grayish brown to dark brown in a hue of 10YR or 7.5YR. The B horizon ranges from heavy clay loam to clay and becomes less clayey as depth increases. It ranges from reddish brown to yellowish red in hue of 5YR or 2.5YR. In some places strata of clay occur in the C horizon. McLain silt loam is less clayey throughout the profile than the profile described.

MILLER SERIES

The Miller series consists of reddish, somewhat poorly drained, calcareous, clayey soils on bottom land of the Salt Fork Arkansas River.

Unlike the Lela soils, the Miller soils have a reddish-brown AC horizon and are calcareous throughout. The Miller soils are more clayey than the associated Yahola soils and are more reddish and more calcareous than the McLain soils.

Profile of Miller clay in a cultivated field (300 feet east and 100 feet north of southwest corner of southeast quarter of sec. 5, T. 25 N., R. 2 W.):

A1—0 to 10 inches, reddish-brown (5YR 4/3) clay, dark reddish brown (5YR 5/3) when moist; weak, medium, granular structure to massive; very sticky and plastic when wet, extremely hard when dry; few fine roots and pores; calcareous; abrupt boundary.

AC—10 to 19 inches, reddish-brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) when moist; weak, fine, blocky structure to massive; very sticky and plastic when wet; very slowly permeable; few fine roots and worm casts; few, small, scattered concretions of calcium carbonate; calcareous; gradual boundary.

C1—19 to 29 inches, yellowish-red (5YR 5/6) light clay loam, reddish brown (5YR 4/4) when moist; weak, fine and medium, granular structure; pockets of material from the AC horizon interspersed in the upper part of this horizon; friable when moist, slightly hard when dry; calcareous; clear boundary.

C2—29 to 44 inches, yellowish-red (5YR 5/6) very fine sandy loam, yellowish red (5YR 4/6) when moist; weak, fine, granular structure; very friable when moist; permeable; calcareous; gradual boundary.

C3—44 to 60 inches +, reddish-yellow (5YR 6/6) fine sand, yellowish red (5YR 4/6) when moist; structureless; loose when moist; calcareous.

The A1 horizon ranges from dark brown to reddish brown. It is generally clay but is fine sandy loam in small areas. The A horizon ranges from mildly alkaline to calcareous; and lower horizons are calcareous. The depth to sandy or loamy material ranges from 20 to 44 inches or more but averages about 26 inches. The AC horizon ranges from 8 to 28 inches in thickness and from brown to reddish brown in hues of 5YR and 7.5YR. The C horizon ranges from dark reddish brown to reddish yellow and commonly contains strata of sandy to clayey material.

NEWTONIA SERIES

In the Newtonia series are deep, brown, granular soils that developed in residuum from limestone or limestone interbedded with calcareous shale.

The Newtonia soils are more brownish than the Summit soils and have less clay in the B horizon. Generally, the limestone underlying the Newtonia soils has less interbedded shale and clay than the limestone underlying the Summit soils. The Newtonia soils are distinguished from Labette soils by a less clayey, more granular B2t horizon. They are less grayish and deeper than the very shallow, associated Sogn soils. Unlike the Norge soils, the Newtonia soils have strong granular structure in the subsoil and developed from weathered limestone rather than ancient alluvial material.

Profile of Newtonia silt loam in a cultivated field (1,000 feet south and 75 feet east of northwest corner of sec. 28, T. 27 N., R. 3 E.):

Ap—0 to 9 inches, brown (7.5YR 4/3) silt loam, dark brown (7.5YR 3/3) when moist; moderate, medium, granular structure; very friable when moist, slightly hard when dry; pH 6.5; abrupt boundary.

B1—9 to 16 inches, reddish-brown (5YR 4/3) silty clay loam, dark reddish brown (5YR 3/3) when moist; strong, medium and coarse, granular structure; friable when moist, hard when dry; abundant pinholes, worm casts, and roots; pH 6.5; gradual boundary.

B21t—16 to 29 inches, reddish-brown (5YR 4/4) heavy silty clay loam, dark reddish brown (5YR 3/4) when moist; strong, medium and coarse, granular structure; friable when moist, hard when dry; pH 6.5; gradual boundary.

B22t—29 to 44 inches, reddish-brown (5YR 4/4) heavy silty clay loam, dark reddish brown (5YR 3/4) when moist; weak, medium, subangular blocky structure breaking to strong, medium and coarse, granular structure; firm when moist, very hard when dry; few black films and concretions; pH 6.5; gradual boundary.

B3—44 to 60 inches, yellowish-red (5YR 4/6) light silty clay, dark red (2.5YR 3/6) when moist; few, fine, faint mottles of grayish brown; weak, medium, subangular blocky structure; firm when moist, extremely hard when dry; contains few, fine, black films and concretions that probably are oxides of manganese and iron; pH 7.0.

The A horizon ranges from brown to dark brown in a hue of 7.5YR. This horizon is mainly silt loam, but it is light silty clay loam in small areas. The B horizon ranges from dark brown to dark reddish brown in a hue

of 7.5YR or 5YR. It generally is heavy silty clay loam but ranges to light clay. The B horizon ranges from slightly acid to mildly alkaline. The B3 horizon ranges from brown to reddish yellow in a hue of 7.5YR or 5YR. The texture ranges from silty clay loam to silty clay. Limestone is commonly at a depth ranging from 50 to 80 inches or more.

NORGE SERIES

The Norge series consists of deep, well-drained soils on remnants of ancient stream terraces and alluvial plains. These soils developed in neutral to alkaline clayey sediments.

Norge soils are lighter colored than the Kirkland soils and, unlike them, lack a claypan. They are more brownish than the Bethany soils and have a less clayey subsoil. The Norge soils are less silty throughout the profile than the Vanoss soils and have a more reddish subsoil. They are less sandy than Shellabarger soils.

Profile of Norge loam in a cultivated field (200 feet east and 85 feet south of northwest corner of northeast quarter sec. 30, T. 27 N., R. 1 E.):

Ap—0 to 8 inches, brown, (7.5YR 4/3) loam, dark brown (7.5YR 3/3) when moist; moderate, medium and fine, granular structure; very friable when moist; slightly hard when dry; numerous roots and pinholes; pH 5.6; abrupt boundary.

B1—8 to 16 inches, brown (7.5YR 4/3) clay loam, dark brown (7.5YR 3/3) when moist; moderate, medium, subangular blocky structure breaking to moderate, medium, granular structure; friable when moist, hard when dry; numerous pinholes; pH 6.0; gradual boundary.

B2t—16 to 32 inches, reddish-brown (5YR 4/4) heavy clay loam, dark reddish brown (5YR 3/4) when moist; moderate, medium, subangular blocky structure; firm when moist, very hard when dry; numerous pinholes and worm casts; many sand grains of uniform size on the surfaces of peds; pH 6.0; gradual boundary.

B3—32 to 53 inches, yellowish-red (5YR 4/6) heavy clay loam, dark reddish brown (5YR 3/4) when moist; moderate, medium, subangular blocky structure; firm when moist, very hard when dry; contains numerous particles of fine sand; pH 6.5; gradual boundary.

C—53 to 60 inches, yellowish-red (5YR 5/6) heavy clay loam, yellowish red (5YR 4/6) when moist; moderate, medium, subangular blocky structure; firm when moist, very hard when dry; few fine roots along the surfaces of peds; abundant small sand grains throughout horizon; pH 6.5.

The A horizon is generally loam, but it is silt loam in small areas. This horizon ranges from dark brown to brown in a hue of 10YR or 7.5YR. It is medium acid to slightly acid. The B1 horizon ranges from light clay loam to heavy clay loam and is 6 to 10 inches thick. The B2t horizon ranges from heavy clay loam to light clay and, in a hue of 5YR, from reddish brown to dark reddish brown. A few waterworn pebbles of quartz or quartzite commonly occur throughout the profile. The C horizon ranges from light clay loam to clay and from yellowish red through reddish brown to red in hue of 5YR or 2.5YR. Reaction of B and C horizons ranges from medium acid to neutral.

OWENS SERIES

The Owens series is made up of excessively drained, shallow, calcareous soils that developed in material of the Wellington formation. Slopes are moderate to steep.

Compared with Vernon soils, Owens soils have a darker, more granular A horizon and an olive rather than reddish C horizon. The Owens soils are less deep to the substratum than the Summit soils. They are deeper than the very shallow Sogn soils, which are underlain by hard limestone.

Profile of Owens clay in native pasture (1,800 feet south and 190 feet west of northeast corner of sec. 23, T. 28 N., R. 2 W.):

A1—0 to 5 inches, grayish-brown (2.5Y 5/2) clay, very dark grayish brown (2.5Y 3/2) when moist; strong, coarse, granular structure; many roots; many small fragments of shale throughout horizon; calcareous; abrupt boundary.

AC—5 to 20 inches, light olive-gray (5Y 6/2) clay, olive gray (5Y 4/2) when moist; few, faint mottles of light olive brown (2.5Y 5/4); compound strong, coarse, granular structure to massive; very hard when dry; few roots; partly weathered Wellington formation; calcareous; gradual boundary.

C1—20 to 36 inches, olive-gray (5Y 5/2) raw clay of the Wellington formation, olive gray (5Y 4/2) when moist; distinct, common mottles of light gray (5Y 7/2) and olive brown (2.5Y 4/4); few fine roots; calcareous; gradual boundary.

C2—36 to 60 inches, light olive-gray (5Y 6/2) raw clay of the Wellington formation, olive gray (5Y 5/2) when moist; less mottled than C1 horizon; very few fine roots; calcareous.

The A horizon ranges from heavy clay loam to clay and from dark grayish brown or grayish brown to olive gray in a hue of 2.5Y or 5Y. The depth to unweathered olive shale and clay ranges from 4 to 20 inches. Thin strata of reddish-brown material occur in places below a depth of 18 inches. Bare outcrops of bluish-gray shale are common. The C horizon consists of raw clays and shales of the Wellington formation. In many places it is mottled with various shades of gray, brown, and olive. All horizons are typically calcareous.

PORT SERIES

In the Port series are dark-brown to brown soils on flood plains along rivers and other large streams. These soils formed in neutral silty sediments from Permian redbeds. In some places these sediments are calcareous.

The Port soils are more brownish than the Kaw soils and are less clayey than the Brewer and McLain soils. Compared with Reinach soils, Port soils are more silty and less loamy below a depth of 9 inches, are more stratified with heavier material, and are slightly darker colored. Unlike McLain soils, they do not have a B2 horizon. The Port soils are less stratified than the Yahola soils and are flooded less often.

Profile of Port silt loam in a cultivated field (300 feet west and 50 feet north of southeast corner of sec. 25, T. 27 N., R. 1 W.):

A1p—0 to 9 inches, brown (10YR 4/3) silt loam, dark brown (10YR 3/3) when moist; moderate, medium and fine, granular structure; friable when moist, hard when dry; pH 6.5; clear boundary.

A12—9 to 14 inches, brown (7.5YR 4/4) silt loam, dark brown (7.5YR 3/2) when moist; crushes to slightly more brownish color; moderate, medium, granular structure; friable when moist, hard when dry; many pinholes and worm casts; pH 6.8; gradual boundary.

AC—14 to 36 inches, reddish-brown (5YR 4/4) light silt loam, dark reddish brown (5YR 3/4) when moist; weak, fine and medium, granular structure; friable

when moist, hard when dry; some worm casts, pinholes, and roots; pH 7.0; gradual boundary.

C—36 to 60 inches, reddish-brown (5YR 5/4) silty clay loam, dark reddish brown (5YR 3/4) when moist; weak, fine, granular structure; firm when moist, very hard when dry; pH 7.0.

The A horizon ranges from brown to reddish brown. This horizon is generally silt loam, but it is heavy silt loam to light silty clay loam in small areas that adjoin Brewer soils. The AC and C horizons range from brown or reddish brown to yellowish red in a hue of 7.5YR or 5YR. The Port soils are darker colored in small areas along the Chikaskia River than they are along the Salt Fork Arkansas River. In some places a dark layer, which was formerly the surface layer of a buried soil, occurs at a varying depth. Deep in the profile in some areas are very slowly permeable bands of clay. Reaction ranges from slightly acid to neutral in the A horizon. The lower part of the AC or the C horizon is calcareous in some places.

PRATT SERIES

The Pratt series consists of deep loamy fine sands on hummocky uplands These soils have a neutral to medium acid surface layer, and they lack free lime throughout the solum.

Pratt soils are coarser textured than the Shellabarger soils and unlike them do not have a sandy clay loam subsoil. Pratt soils lack the light colored A2 horizons of Dougherty and Eufaula soils.

Profile of Pratt loamy fine sand in a native pasture (1,600 feet west and 50 feet north of southeast corner of sec. 21, T. 26 N., R. 2 W.):

A1—0 to 11 inches, grayish-brown (10YR 5/2) loamy fine sand, very dark grayish brown (10YR 3/2) when moist; single grain to very weak, fine, granular structure; loose when moist or dry; numerous roots; pH 6.0; clear boundary.

B2—11 to 40 inches, brown (7.5YR 5/4) loamy fine sand, dark brown (7.5YR 4/4) when moist; porous; massive; loose when moist or dry; horizontal bands of slightly darker sandy loam ¼ to ½ inch thick; numerous roots; pH 6.0; gradual boundary.

C—40 to 60 inches, similar to B2 horizon except that horizontal bands of sandy loam are absent and roots are few.

The A horizon ranges from grayish brown to brown. It is darker to a greater depth between the knobs and ridges than on them. The A horizon is generally loamy fine sand, but ranges from loamy sand to light fine sandy loam. Narrow bands of sandy loam to light sandy clay loam occur throughout the B2 horizon. The B2 is a fine sandy loam in places. It ranges from 10 to 30 inches in thickness and from brown to brownish yellow in hues of 10YR and 7.5YR. Reaction is medium acid to neutral in the A horizon and medium acid to alkaline in lower horizons.

REINACH SERIES

The Reinach series consists of deep, friable soils that, in this county, occur on low, seldom flooded terraces of the Chikaskia and Salt Fork Arkansas Rivers. These soils formed in calcareous loamy and sandy loam that washed from subhumid plains underlain by redbeds.

The Reinach soils are younger than the closely associated Port soils and have a more loamy, more uniform profile that lacks stratification in the upper 4 feet. Compared with the Yahola soils, Reinach soils are less sandy, slightly darker, less calcareous, and less frequently flooded. They have a lighter colored A horizon than the Brewer and McLain soils, are less clayey in the subsoil, and are more permeable.

Profile of Reinach loam in an alfalfa field (1,920 feet north and 60 feet west of southeast corner of sec. 17, T. 25 N., R. 1 W.):

Ap—0 to 9 inches, brown (10YR 4/3) loam, dark brown (10YR 3/3) when moist; weak, medium and fine, granular structure; very friable when moist, soft when dry; pH 6.1; abrupt boundary.

A1—9 to 17 inches, brown (7.5YR 4/4) loam, dark brown (7.5YR 3/2) when moist; moderate, medium and fine, granular structure; very friable when moist, soft when dry; numerous fine roots and pinholes; pH 6.5; gradual boundary.

AC—17 to 30 inches, brown (7.5YR 4/4) loam, dark brown (7.5YR 3/2) when moist, slightly more reddish than A1 horizon; weak, fine, granular structure; very friable when moist, soft when dry; abundant pinholes; pH 6.8; gradual boundary.

C—30 to 60 inches, yellowish-red (5YR 5/6) loam, reddish brown (5YR 4/4) when moist; weak, fine, granular structure; very friable when moist, soft when dry; pH 8.0.

The A horizon is generally loam, but it ranges from light silt loam in some areas along the Chikaskia River to very fine sandy loam on lower terraces of the Salt Fork Arkansas River. The A horizon ranges from dark brown to brown in a hue of 10YR or 7.5YR. The AC and C horizons range from brown to yellowish red. The AC horizon is dominantly neutral, and the C horizon is generally neutral. In some places the C horizon is calcareous. At a depth of 24 to 34 inches is weak granular light loam to very fine sandy loam.

RENFROW SERIES

The Renfrow series is made up of deep, dark-brown, very slowly permeable, clayey soils on uplands. These soils formed in clay and shale of the Garber and Wellington formations.

The Renfrow soils are more reddish than the dark-colored Kirkland soils. They are deeper over raw clay and shale than the Vernon soils. Renfrow soils have more clayey B horizons than Norge soils.

Profile of Renfrow silt loam in a native pasture (400 feet north and 40 feet east of southwest corner of northwest quarter of sec. 25, T. 25 N., R. 2 W.):

A1—0 to 6 inches, brown (7.5YR 4/2) silt loam, dark brown (7.5YR 3/2) when moist; moderate, medium, granular structure; friable when moist; slightly hard when dry; abundant roots and worm casts; pH 6.5; gradual boundary.

B1—6 to 12 inches, reddish-brown (5YR 4/3) light clay loam, dark reddish brown (7.5YR 3/2) when moist; weak, medium, subangular blocky structure breaking to strong, medium and coarse, granular structure; friable when moist, hard when dry; abundant roots and worm casts; pH 6.5; clear boundary.

B21t—12 to 21 inches, reddish-brown (5YR 4/3) clay, dark reddish brown (5YR 3/3) when moist; weak, fine, blocky structure; peds have shiny surfaces when moist; very firm when moist, extremely hard when dry; very slowly permeable; few concretions of calcium carbonate; pH 7.0; gradual boundary.

B22t—21 to 30 inches, reddish-brown (5YR 4/4) clay, dark reddish brown (5YR 3/4) when moist; weak, fine, blocky structure to massive; very firm when moist, extremely hard when dry; very slowly permeable;

few fine roots; concretions of calcium carbonate; mildly calcareous; gradual boundary.

B3—30 to 60 inches +, reddish-brown (5YR 5/4) clay, reddish brown (5YR 4/4) when moist; weak, fine, granular structure; massive; compact; very slowly permeable; strongly calcareous.

The A horizon ranges from brown to reddish brown in a hue of 5YR or 7.5YR. The texture of the A horizon is dominantly silt loam, but it is clay loam in some eroded areas. The B2 horizons range from dark reddish brown in a hue of 5YR or 2.5YR. In many places where Renfrow soils adjoin Kirkland soils, the B2 horizons are less reddish than typical. In uneroded areas the depth to the B21t horizon ranges from 8 to 14 inches. The depth to the B3 horizon ranges from 20 to 36 inches. Reaction ranges from slightly acid to neutral in the A horizon and is generally neutral in the lower horizons. In some places the lower horizons are calcareous.

SHELLABARGER SERIES

The Shellabarger series consists of well-drained soils on uplands. These soils developed from slightly acid to medium acid old alluvium or loamy eolian deposits.

The Shellabarger soils have a thicker, more loamy A horizon and a more clayey B horizon than the Pratt soils. The B horizon of Shellabarger soils is less clayey than that of the Norge soils. Shellabarger soils lack an A2 horizon, which occurs in the Dougherty and Eufaula soils.

Profile of Shellabarger fine sandy loam in a native meadow (500 feet east of southwest corner of sec. 27, T. 27 N., R. 4 E.):

A1—0 to 8 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, very dark brown (10YR 2/2) when moist; moderate, medium and fine, granular structure; friable when moist, soft when dry; permeable; abundant roots; pH 6.0; clear boundary.

A3—8 to 12 inches, dark grayish-brown (10YR 4/2) fine sandy loam, very dark grayish brown (10YR 3/2) when moist; weak, medium and fine, granular structure; friable when moist, soft when dry; permeable; many roots and grains of quartz; pH 6.0; gradual boundary.

B1—12 to 16 inches, brown (10YR 4/3) heavy fine sandy loam, dark brown (10YR 3/3) when moist; weak and moderate, medium, granular structure; friable when moist, soft to slightly hard when dry; permeable; roots, pinholes, and worm casts present; pH 6.0; gradual boundary.

B2—16 to 28 inches, brown (7.5YR 4/4) sandy clay loam, dark brown (7.5YR 3/2) when moist; compound weak, medium and fine, subangular blocky structure and weak, coarse and medium, granular structure; friable when moist, slightly hard and hard when dry; moderately permeable; numerous roots and pinholes; dull shine on surfaces of peds; pH 6.0; gradual boundary.

B3—28 to 42 inches, reddish-brown (5YR 4/4) light sandy clay loam, dark reddish brown (5YR 3/4) when moist; compound weak, coarse and medium, subangular blocky structure and weak, medium and fine, granular structure; moderately permeable; few fine roots and pinholes; grains of quartz and feldspar; pH 6.0; gradual boundary.

C—42 to 60 inches, yellowish-red (5YR 5/6) sandy loam, yellowish red (5YR 4/8) when moist; very weak, medium and fine, granular structure; many single grains of quartz and feldspar; very friable when moist, slightly hard when dry; permeable; few fine roots and pinholes; pH 6.0.

The A1 horizon is generally fine sandy loam, but it is loamy fine sand in local spots that have been recently eroded by the wind. The A1 and A3 horizons generally range from dark grayish brown to dark brown in a hue of 10YR or 7.5YR, but in small areas in the western part of the county along the Salt Fork Arkansas River, these horizons are less grayish. The B2 and B3 horizons range from brown to dark reddish brown in a hue of 7.5YR or 5YR. The A and B horizons range from slightly acid to medium acid.

SOGN SERIES

The Sogn series consists of very shallow, dark-colored soils on uplands. These soils developed from hard limestone in the eastern part of the county, and they generally have fragments of limestone on the surface. Most areas are small.

Sogn soils are much thinner and less well developed than the Summit and Newtonia soils. They are darker and less clayey than Vernon soils which developed from reddish-brown clay. Sogn soils are very shallow over limestone, whereas the Owens soils are shallow over dark-colored clays and shale.

Profile of Sogn soils in a native pasture (1,060 feet north and 35 feet west of southeast corner of sec. 18, T. 29 N., R. 5 E.):

A—0 to 9 inches, very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) when moist; strong, coarse and medium, granular structure; friable when moist; numerous roots; pH 6.0; abrupt, irregular boundary.

R—9 to 12 inches +, very pale brown limestone broken by vertical cracks where limestone has weathered; material from A horizon fills some cracks to a depth of about 15 inches; few grass roots penetrate crevices to a depth of several feet.

The A horizon ranges from very dark gray to very dark brown in a hue of 10YR. This layer ranges from silty clay loam or stony clay loam to silt loam. Thickness of the A horizon may range from 2 to 15 inches in a short distance. The boundary between the A horizon and the R horizon ranges from gradual to abrupt. Exposed limestone generally covers about 15 percent of the surface, but the range is from 5 to 30 percent.

SUMMIT SERIES

The Summit series consists of very dark, granular soils that developed in residuum from interbedded limestone and shale in the Bluestem Hills in the northeastern part of the county. The Summit soils occur with the Sogn soils, which have limestone at or near the surface.

The Summit soils have a darker surface layer than the Labette soils and a heavier B2t horizon that is very dark grayish brown or almost black in the upper part instead of brown to reddish brown. They are darker and more clayey than Newtonia soils.

Profile of Summit silty clay loam in a native pasture (1,900 feet south and 50 feet east of northwest corner of sec. 20, T. 29 N., R. 5 E.):

A1—0 to 15 inches, very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) when moist; strong, coarse and medium, granular structure; friable when moist, slightly hard when dry; abundant roots and worm casts; pH 5.6; clear boundary.

B2t—15 to 23 inches, very dark grayish-brown (10YR 3/2) heavy silty clay loam, dark brown (10YR 2/2) when moist; few, fine, faint mottles of olive brown; mod-

erate, medium, blocky structure; very firm when moist, very hard when dry; few small concretions of iron and fragments of chert; abundant roots; pH 6.0; gradual boundary.

B3—23 to 32 inches, brown (10YR 4/3) clay, dark brown (10YR 3/3) when moist; moderate, medium, blocky structure; very firm when moist, very hard when dry; few concretions of iron and fragments of chert; pH 6.5; gradual boundary.

C—32 to 42 inches +, brown (10YR 4/3) clay, dark brown (10YR 3/3) when moist; massive; 3 to 5 percent of soil mass is chert and partly weathered limestone; few fine roots; pH 7.0.

The A horizon ranges from dark gray or very dark gray to very dark grayish brown in a hue of 10YR. It is mainly silty clay loam but is clay loam in some places. The B horizon ranges from dark brown to very dark grayish brown and from heavy silty clay loam to clay. Below the B horizon, the color ranges to olive brown in a hue of 2.5Y and dark gray in a hue of 10YR. In areas east of Little Beaver Creek, many fragments of chert occur in the lower horizons. The depth to bedrock ranges from 24 inches to more than 5 feet. Reaction ranges from medium acid in the A horizon to alkaline in the C horizon.

TABLER SERIES

The Tabler series consists of deep, dark-colored soils that have a claypan. These soils developed in calcareous to alkaline sediments of clay to heavy clay on nearly level uplands or terraces.

The Tabler soils are more grayish and are darker below the A horizon than the associated Kirkland and Renfrow soils. They are more grayish than the associated Bethany soils but unlike them lack a B1 horizon.

Profile of Tabler silt loam in a cultivated field (250 feet south and 150 feet east of northwest corner of southwest quarter of sec. 2, T. 27 N., R. 2 W.):

Ap—0 to 8 inches, dark-gray (10YR 4/1) silt loam, very dark gray (10YR 3/1) when moist; weak, fine, granular structure; friable when moist, soft to slightly hard when dry; numerous pinholes; pH 5.8; abrupt boundary.

B2t—8 to 27 inches, very dark gray (10YR 3/1) clay, black (10YR 2/1) when moist; weak, medium, blocky structure when dry, massive when moist; pronounced clay films on the surfaces of peds; very firm and compact when moist, extremely hard when dry; very slowly permeable; slightly acid in upper part, neutral in lower part; gradual boundary.

B3—27 to 38 inches, dark grayish-brown (10YR 4/2) clay, very dark grayish brown (10YR 3/2) when moist; weak, fine, blocky structure to massive; very firm when moist, extremely hard when dry; few concretions of calcium carbonate in lower part; gradual boundary.

C—38 to 48 inches, brown (10YR 4/3) silty clay, dark brown (10YR 3/3) when moist; common, fine, faint mottles of dark yellowish brown and gray; weak, fine, blocky structure to massive; very firm when moist, very hard when dry; few fine roots; pH 8.0.

The A horizon is generally silt loam, but it is light clay in small areas. It ranges from gray to dark grayish brown in a hue of 10YR. Thickness of the A horizon ranges from 6 to 14 inches. The aggregates in the lower part of the A horizon commonly are faintly coated with gray. The boundary between the A and B horizons is abrupt or clear. The B2t horizon ranges from dark gray to very dark grayish brown in a hue of 10YR. Mottles in the C horizon are gray, yellowish brown, and reddish brown. The C horizon ranges from clay to heavy clay loam. Generally, concretions of calcium carbonate occur at a depth of 30 inches, and the soil mass is calcareous at 40 inches.

VANOSS SERIES

The Vanoss series consists of deep, well-drained soils on high terraces. These soils developed in friable, eolian and alluvial, silty or loamy sediments of Pleistocene or Recent age that are relatively high in weatherable minerals.

The Vanoss soils are less reddish than Norge soils. The Bt horizon of the Vanoss soils contain less clay and is more permeable than the Bt horizon of the Bethany soils. Vanoss soils are less sandy than Shellabarger soils.

Profile of Vanoss silt loam in a cultivated field (1,900 feet west and 100 feet north of southeast corner of sec. 22, T. 28 N., R. 3 E.):

A1—0 to 12 inches, brown (10YR 5/3) silt loam, dark brown (10YR 3/3) when moist; moderate, medium and fine, granular structure; friable when moist, soft when dry; pH 6.0; gradual boundary.

A3—12 to 16 inches, brown (10YR 4/3) light clay loam, dark brown (10YR 3/3) when moist; crushes to slightly more brownish color; moderate, medium, granular structure; friable when moist, soft when dry; pH 6.0; gradual boundary.

B21t—16 to 24 inches, brown (7.5YR 4/4) silty clay loam, dark brown (7.5YR 3/2) when moist; compound moderate, medium, subangular blocky structure and moderate, coarse and medium, granular structure; friable when moist, slightly hard when dry; abundant worm casts; pH 6.0; gradual boundary.

B22t—24 to 38 inches, brown (7.5YR 4/4) silty clay loam, dark brown (7.5YR 3/4) when moist; moderate, coarse, prismatic structure; firm when moist, slightly hard when dry; very few fine roots; pH 6.0; gradual boundary.

C—38 to 54 inches, reddish-brown (5YR 4/4) silty clay loam, dark reddish brown (5YR 3/4) when moist; moderate, coarse, prismatic structure; firm when moist, slightly hard when dry; pH 6.0.

The A1 horizon ranges from brown to dark brown in a hue of 10YR or 7.5YR. This horizon is silt loam in most places but is light loam in small areas. The surface layer is more silty along the Arkansas River than it is along the Salt Fork Arkansas River. The B horizons range from silty clay loam to clay loam in texture and from brown to yellowish red in color. The C horizon ranges from silty clay loam to light clay loam in texture and is neutral to mildly alkaline.

VERNON SERIES

The Vernon series consists of gently sloping to sloping, clayey soils that are shallow over reddish, calcareous, compact clay of Permian age.

The Vernon soils are more reddish and more shallow than the Renfrow and Kirkland soils and are more reddish than the Owens soils. Unlike the Owens soils, which developed in material from the Wellington formation, Vernon soils developed in material from the Garber formation.

Profile of Vernon clay loam in a cultivated field (90 feet south and 120 feet east of northwest corner of sec. 26, T. 25 N., R. 2 W.):

Ap—0 to 6 inches, reddish-brown (5YR 4/3) heavy clay loam, dark reddish brown (5YR 3/3) when moist; weak, medium, granular structure to massive; firm when

moist, very hard when dry; fragments of siltstone and shale on surface; calcareous; abrupt boundary.

AC—6 to 13 inches, reddish-brown (5YR 4/3) clay, dark reddish brown (5YR 3/3) when moist; weak, fine and medium, blocky structure approaching massive; very firm when moist, extremely hard when dry; calcareous; gradual boundary.

C—13 to 60 inches, reddish-brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) when moist; massive; compact; essentially unaltered clayey red-bed material; concretions of calcium carbonate; calcareous.

The A horizon ranges from dark reddish brown to brown in a hue of 7.5YR or 5YR. This horizon is clay loam in most places but ranges to clay. The AC and C horizons range from reddish brown or red to strong brown in a hue of 7.5YR or 2.5YR. Weakly consolidated compact clay and shale occur at a depth of 10 to 20 inches. In places small fragments of shale occur on the surface. In some places the surface layer is mildly alkaline.

WAURIKA SERIES

The Waurika series consists of deep, dark-colored soils that have a claypan. These soils are in level or slightly depressional areas. They have medium acid A horizons that are less than 14 inches thick. The boundary between the A2 horizon and B2t horizon is abrupt or clear.

A gray A2 horizon distinguishes Waurika soils from the associated Tabler soils. Waurika soils are more grayish than the associated Bethany soils and, unlike them, lack a B1 horizon. Waurika soils are more grayish and less sloping than the Kirkland and Renfrow soils, which do not have an A2 horizon.

Profile of Waurika silt loam in a cultivated field (365 feet north and 100 feet east of southwest corner of sec. 4, T. 25 N., R. 1 E.):

Ap—0 to 9 inches, gray (10YR 5/1) silt loam, very dark grayish brown (10YR 3/2) when moist; massive; very friable when moist, slightly hard when dry; many fine roots; numerous pinholes; pH 5.7; abrupt, smooth boundary.

A2—9 to 12 inches, gray (10YR 6/1) silt loam, dark gray (10YR 4/1) when moist; massive; very friable when moist, slightly hard to soft when dry; few fine roots; numerous pinholes; pH 6.5; clear, wavy boundary.

B21t—12 to 32 inches, dark-gray (10YR 4/1) silty clay, black (10YR 2/1) when moist; few, fine, faint mottles of brown; weak, fine, blocky structure; very firm when moist, extremely hard when dry; moderate continuous clay films; light-colored soil material similar to that in the A2 horizon is on some vertical surfaces of peds; few fine roots; very slow permeability; pH 7.0; diffuse, smooth boundary.

B22t—32 to 36 inches, very dark gray (10YR 3/1) silty clay, very dark grayish brown (10YR 3/2) when moist; few, fine, faint mottles of strong brown; weak, fine, blocky structure; very firm when moist, extremely hard when dry; clay films on the surfaces of peds; light-colored soil material similar to that in A horizon is along the vertical cleavage planes; few single grains of sand on the surfaces of peds; fine roots common along surfaces of peds; pH 7.7; gradual boundary.

B31—36 to 42 inches, dark-gray (10YR 4/1) silty clay, very dark grayish brown (10YR 3/2) when moist; few, fine, faint mottles of strong brown; weak, fine, blocky structure; extremely firm when moist, extremely hard when dry; few very fine roots; few concretions of calcium carbonate; pH 8.3; gradual boundary.

B32—42 to 64 inches, dark grayish-brown (10YR 4/2) heavy silty clay loam, very dark grayish brown (10YR 3/2) when moist; few, fine, faint mottles of strong brown; weak, fine, blocky structure; extremely firm when moist, extremely hard when dry; pH 7.8; gradual boundary.

C1—64 to 76 inches, dark grayish-brown (10YR 4/2) silty clay loam, very dark grayish brown (10YR 3/2); common, fine, distinct mottles of dark yellowish brown; weak, fine, blocky structure; extremely firm when moist, extremely hard when dry; pH 7.5; gradual boundary.

C2—76 to 106 inches, dark yellowish-brown (10YR 4/4) clay loam, dark yellowish brown (10YR 3/4) when moist; common, distinct mottles of light brownish gray (10YR 6/2) and yellowish brown (10YR 5/6); massive; extremely firm when moist, extremely hard when dry; few, fine, black concretions; pH 7.1.

The A horizon ranges from gray to dark grayish brown. The A2 horizon is 2 to 5 inches thick, but part or all of this horizon may be mixed into the plow layer where the Ap horizon is thin. The B horizon is silty clay or clay that has a content of clay of 40 to 60 percent. This layer ranges from dark gray to very dark grayish brown in a hue of 10YR. The C horizon is clay to clay loam and is commonly mottled. Reaction ranges from medium acid in the A horizon to alkaline in the lower horizons. In some places the lower horizons are calcareous.

YAHOLA SERIES

The Yahola series is made up of loamy to sandy alluvial soils along the Salt Fork Arkansas and Chikaskia Rivers. Recurrent floods add fresh soil material to the surface during each flood.

Because of the more flooding and more frequent deposits of fresh material, Yahola soils have less well developed horizons than Reinach soils. Yahola soils are more sandy than the associated clayey Miller soils. They are less sandy than the Lincoln soils and more sandy than Port soils.

Profile of Yahola fine sandy loam in a cultivated field (1,320 feet north and 80 feet east of southwest corner of sec. 1, T. 25 N., R. 2 W.):

Ap—0 to 9 inches, brown (7.5YR 4/4) fine sandy loam, dark brown (7.5YR 3/2) when moist; weak, fine, granular structure; very friable when moist, soft when dry; numerous roots; calcareous; clear boundary.

AC—9 to 23 inches, light-brown (7.5YR 6/4) loamy fine sand, brown (7.5YR 4/4) when moist; structureless; very friable when moist, loose when dry; numerous roots; calcareous; wavy boundary.

C1—23 to 35 inches, reddish-brown (5YR 4/4) heavy loam, dark reddish brown (5YR 3/4) when moist; moderate, medium and fine, granular structure; friable when moist; some stratified sandier and clayey material; calcareous; clear, wavy boundary.

C2—35 to 60 inches, yellowish-red (5YR 5/6) loamy fine sand, yellowish red (5YR 4/6) when moist; structureless; loose when dry; permeable; calcareous.

The A horizon ranges from light brown or brown to reddish brown and is neutral or calcareous. Stratified sand, silt, or clay may occur at any depth in the profile. The texture of the A horizon ranges from fine sandy loam to loamy fine sand with the dominant texture depending on the type. A fine sandy loam and loamy fine sand type of Yahola were mapped in this county. Texture of the AC and C horizons ranges from loamy fine sand to light loam. These soils are calcareous between 10 and 20 inches and are generally calcareous to the surface.

Physical and Chemical Properties

This subsection contains a general discussion of physical and chemical properties of the soils in Kay County. The information is based on studies of data on the soils of this county and the surrounding counties.

In most soils of the county the content of organic matter and the percentage of nitrogen decrease as depth increases. The carbon-nitrogen ratio is wide in the surface layer and tends to decrease with depth.

The fertility of soils is affected by their capacity to hold exchangeable cations or their cation-exchange capacity. Generally, the coarser textured soils have a lower cation-exchange capacity than medium- and fine-textured soils. For example, cation-exchange capacity is about 5.0 in the A horizon of the Dougherty soils and about 15.0 in the A horizon of the more silty Bethany soils. Most soils in the county have a greater content of clay and a higher cation-exchange capacity in the subsoil than in the surface layer. The cation-exchange capacity is commonly about 10.0 in the subsoil of the Dougherty soils but is about 30.0 in the more clayey subsoil of Bethany soils.

Plant nutrients, such as calcium, magnesium, sodium, and potassium, held as exchangeable bases, are readily available to plants but are not readily leached from the soils. Chemical data indicate that there are substantial reserves of calcium, magnesium, and potassium in the subsoil of the soils in the important series in the county. Most well-expressed profiles have more exchangeable calcium, magnesium, and potassium, as well as greater base saturation, in the B horizon than in the A horizon. Evidence indicates that the more available forms of phosphorus have been depleted in the past few years.

In most soils in this county, calcium and magnesium are the controlling cations in the soil solution, but in some soils exchangeable sodium has replaced the calcium and magnesium. The sodium cation then becomes dominant, and the soil structure rapidly deteriorates. Also, slickspots form on the surface. Where deterioration of this kind has occurred, the soils are less suitable for farming. In Kay County examples of mapping units in which sodium has replaced calcium and magnesium are Lela-Slickspots complex and Labette-Slickspots complex, 3 to 5 percent slopes, eroded.

Among the soils that have a clayey, neutral to alkaline subsoil are the Tabler, Kirkland, Bethany, Renfrow, and Labette. The Norge and Vanoss soils developed on an ancient terrace and have a loamy, slightly acid to neutral subsoil. The subsoil of the Dougherty, Eufaula, and Shellabarger soils is slightly acid.

Reaction, or pH value, expresses the acidity or alkalinity of the soils. The reaction of all soil horizons described in this subsection was determined by field tests. Most of the soils of the county are not strongly acid, because rainfall has not been sufficient to leach a high percentage of bases from the profile. The soils on uplands commonly have a slightly acid to medium acid surface layer, and the soils on bottom lands normally have a slightly acid or calcareous surface layer. Generally, a clay subsoil is alkaline, a loamy subsoil is neutral to slightly acid, and a sandy subsoil is slightly acid.

The dominant clay minerals in the soils of this county are montmorillonite and illite. Kaolinite and vermiculite are also present in lesser amounts. Montmorillonite is prominent in the fine clay fraction, but kaolinite and vermiculite are mainly in the coarse clay fraction. Illite is generally a major component of both the fine and coarse clay fractions, but a much higher percentage is in the coarse clay.

General Nature of the County

This section contains information for those who are not familiar with Kay County. Described are physiography, geology, climate, and other subjects of general interest. The last part of this section contains some facts about agriculture. The figures for population and the statistics on agriculture are mainly from reports of the U.S. Bureau of the Census.

Kay County was once a part of Indian territory called the Cherokee Strip. The Federal government obtained this land from the Cherokee Nation in 1893, and on September 16 of that year, the territory was opened for settlement. Most of the settlers came from Kansas, Nebraska, Missouri, and the Midwestern States.

In 1960 the population of the county was 51,042. Newkirk, the county seat, had a population of 2,092 in 1960. Ponca City, the only city, had a population of 24,411 in 1960. Important towns are Blackwell, Tonkawa, and Braman.

Physiography, Relief, and Drainage

Kay County lies within the Central Rolling Red Prairies and the Bluestem Hills land resource areas. The county is treeless except for narrow strips along streams and in some places on uplands adjacent to the stream bottoms.

The uplands, dominantly smooth on the surface, are mainly level to undulating and gently rolling, and they have many long, very gentle slopes. In the eastern part of the county streams have cut fairly deep drainageways. This cutting has formed steep slopes, a few of them precipitous, and has exposed ledges of limestone. In the central part of the county, the landscape is undulating to gently rolling and slopes are long and rather gentle. The western part of the county is level to gently undulating in an area extending northwestward from Ponca City to Blackwell and Nardin. Level areas are scattered throughout the county.

The level stream terraces and bottom lands vary considerably in width. The terraces or second bottoms along the Arkansas River are only one-half mile wide in most places and in many places are even narrower. The first bottoms range from less than 1/4 mile to about 1 mile in width. Along the Salt Fork Arkansas and the Chikaskia Rivers, the terraces are as much as 2 to 3 miles wide, but only a few first bottoms are more than 1/2 mile wide. Along the smaller streams, the bottom lands are narrow at the upper reaches but widen at the lower reaches, and many are more than one-half mile wide where they flow into the rivers.

The range in elevation throughout the county is small. The county is highest in the eastern part and slopes gradually toward the west. Altitude ranges from 1,300 feet above sea level in the extreme northeast corner to

1,059 feet at the airport west of Blackwell in the western part of the county. Elevation is 1,145 feet at Newkirk and 1,090 feet at Nardin.

The county is drained by the Arkansas River and its tributaries, mainly the Salt Fork Arkansas and the Chikaskia Rivers, and Beaver, Bois d'Arc, Duck, Bitter, and Deer Creeks. The streams are fairly rapid and are deepening their channels.

Drainage throughout the county is good. Almost every square mile of land is drained either by a drainageway or by a slope that grades to a stream. Drainage is better in the more undulating areas than it is in the vicinity of Finley School, west of Ponca City, and in scattered areas in the western and central parts of the county. In these areas the surface is level, and water stands for some time after heavy rains. Also, drainage on the more clayey bottom lands in many places is not adequate for good crop growth.

Geology

Kay County lies mostly in the Central Lowland province of the central part of the Redbed Plains, but the eastern part is in the Northern Limestone Cuesta Plains.

The oldest rocks of the county are in the eastern part and consist of limestone and shale of the Council Grove and Chase groups of the Gearyan series. They are of Permian age. Only the upper part of the Council Grove group remains in the county. It is made up of Cottonwood limestone, 7 feet thick, and of the Garrison formation, consisting of 110 feet of shale and five thin beds of limestone.

The basal unit of the Chase group is Wreford limestone. This limestone is 25 feet thick and supports a prominent escarpment near the Arkansas River. Above Wreford limestone is Matfield shale. It is 95 feet thick and contains a thin bed of a limestone and a local sandstone. The next higher unit of the Chase group is Fort Riley limestone. It is 40 feet thick and is quarried at Uncas. The overlying Doyle shale, 110 feet thick, consists largely of maroon-colored shale but also contains four thin beds of limestone. The Winfield limestone, which is 10 feet thick, forms the escarpment northeast of Ponca City. In some areas, this limestone is quarried. Enterprise shale, 50 feet thick, is overlain by Herington limestone, the highest unit of the Chase group. Herington limestone, 25 feet thick, underlies Ponca City and rims the eastern slope of the city.

Above the Herington limestone is the Leonardian redbed sequence. The western three-fourths of the county is underlain by the Wellington formation, which consists primarily of red shale. In the upper part of the Wellington formation are beds of gray dolomite, greenish-gray shale, and some sandstone. Garber sandstone overlies the Wellington formation in a narrow strip in the northwestern part of the county.

Surficial deposits cover the bedrock in much of the southwestern part of the county. Gravel and sand of Pleistocene age occur in an old alluvial terrace along the Chikaskia River near Braman and in areas west of Ponca City. Alluvium and dune sand are distributed along wide bands in the valleys of the Arkansas, Salt Fork Arkansas, and Chikaskia Rivers.

Climate [9]

Kay County has the temperate, subhumid climate that is typical of the middle part of the northern boundary of Oklahoma. Masses of warm, moist air from the Gulf of Mexico alternate with cooler, moist air from the West Coast or with colder dry air from the Arctic Circle. These changes in air mass often are quite rapid, and they are accompanied by changes in temperature, cloudiness, wind, and precipitation.

Seasonal changes normally vary in intensity, but the changes between seasons are gradual. Cold Canadian air often invades during the winter, and occasionally it is severe enough for temperature to drop sharply and for snow to fall in large enough amounts to leave a cover. Until the southerly winds return, farmers must provide enough additional care, including feed, for their livestock. Precipitation increases markedly during spring, when local storms are most frequent and when occasionally there is a tornado.

Because summer is the hottest and wettest season, winter wheat normally grows rapidly and ripens in time for harvest in June. Periods of hot, dry weather in summer are sometimes lengthened by extended periods of clear skies and persistent winds from the south and west. Generally, however, the rain in local thundershowers is sufficient to provide enough moisture for maintaining pastures, native grass range, and fields of sorghum and small grain.

Fall is a transition period between the heat of summer and the cold of winter. Rainstorms are less frequent in fall than in summer, and the percentage of sunshine is high. Rainfall is considerable early in fall, and it aids the growth of fall pasture and the establishment of winter grain.

Data on temperature and precipitation at Ponca City are given in table 7.

The average annual temperature at Ponca City is 60.9° F. The lowest temperature on record in the county was 25° below zero at White Eagle in February 1905, and the highest was 117° at Newkirk in July 1954. Freezing temperature can be expected on about 84 days a year in Ponca City, but the daily high temperature is below freezing on only 10 of these days. During the long, warm periods from March through October, the temperature reaches 90° on an average of 88 days and 100° on an average of 24 days. At Ponca City degree-days range from none for June through August to a maximum of 865 during January. The annual total is 3,655. Degree-days are based on 65°. In determining the degree-days for a day, the average daily temperature is subtracted from 65. Daily values are totaled to obtain the number of degree-days in a month or a year.

The freeze-free season, or the period when most crops can be safely grown, averages 195 days in the areas around Blackwell and 210 days in the southern part of the county. Freezing temperatures have occurred at Ponca City as late as May 3 in 1954 and as early as October 7 in 1952. Table 8 gives the probabilities of freezing temperatures occurring before October 17 in fall and after April 27 in spring. The data are based on records kept at Newkirk from 1921 to 1950.

[9] By STANLEY G. HOLBROOK, State climatologist, U.S. Weather Bureau.

TABLE 7.—*Temperature and precipitation*

[All data from Ponca City [1]]

Month	Temperature: Average daily maximum	Temperature: Average daily minimum	Temperature: Two years in 10 will have at least 4 days with—: Maximum temperature equal to or higher than—	Temperature: Two years in 10 will have at least 4 days with—: Minimum temperature equal to or lower than—	Precipitation: Average total	Precipitation: One year in 10 will have—: Less than—	Precipitation: One year in 10 will have—: More than—	Precipitation: Days with snow cover of 1 inch or more	Precipitation: Average depth of snow on days with snow cover
	°F.	°F.	°F.	°F.	Inches	Inches	Inches	Number	Inches
January	47. 8	26. 4	67	8	1. 04	0. 1	2. 5	2	2
February	53. 2	29. 8	73	12	1. 23	. 3	2. 2	1	2
March	61. 8	36. 3	79	19	1. 92	. 3	3. 7	1	2
April	73. 0	48. 0	86	32	3. 13	. 6	7. 1	(2)	7
May	81. 1	57. 3	92	44	4. 71	1. 0	10. 5	0	
June	90. 8	66. 7	101	55	4. 43	1. 9	8. 3	0	
July	96. 0	71. 0	105	62	3. 60	. 2	9. 1	0	
August	95. 9	70. 4	107	61	3. 09	. 7	5. 9	0	
September	87. 7	62. 1	100	47	3. 52	. 5	7. 6	0	
October	76. 5	51. 3	91	36	2. 41	. 1	6. 4	0	
November	60. 5	37. 3	76	21	1. 70	(3)	4. 0	(2)	1
December	50. 6	29. 7	67	14	1. 33	. 1	2. 8	1	3
Year	72. 9	48. 9	[4] 107	[5] 1	32. 11	43. 2	21. 2	5	3

[1] Period of record from 1931–60.
[2] Less than 0.5 day.
[3] Trace, amount less than 0.05.
[4] Average annual highest maximum temperature.
[5] Average annual lowest minimum temperature.

Table 7 shows that the average annual precipitation is 32.11 inches at Ponca City. From Ponca City northwestward, precipitation decreases across the county and is only 28.66 inches at Blackwell. At Newkirk annual precipitation has ranged from a record low of 15.54 inches in 1910 to 52.67 inches in 1957. Fortunately, rainfall is greatest during the growing season. On the average, about 35 percent of the annual precipitation occurs in summer, 30 percent in spring, 24 percent in fall, and 11 percent in winter. May is the wettest month, and a secondary peak is in September. January is the driest month. Most months have been dry in some years, but generally a dry month is followed by subsequent hard rains, though they may not come in time to prevent crop loss. Rains of 2 to 4 inches are fairly common. The most rain recorded in a 24-hour period was 5.60 inches at Ponca City in July 1945. Heavy rains wash away soil and seed, or they damage the soils by erosion and siltation.

Annual snowfall averages 9.6 inches at Blackwell and 7.9 at Ponca City. In only about 1 winter in 15 is there no snow. If 3 to 5 inches of snow is left on the ground by a heavy storm, this cover melts in 3 to 5 days after the return of a southerly wind. During the winter of 1948–49, Blackwell received 35.5 inches of snow. Data on snow cover in the county is given in table 7.

In most months the prevailing winds are southerly over Kay County, but late in January and in February, winds blow mostly from the north. The annual average speed of the wind, measured hourly, is 12 miles per hour, but the monthly average ranges from about 10 miles per hour in July to 14 miles per hour in March. Winds of

TABLE 8.—*Probabilities of last freezing temperatures in spring and first in fall*

[All data from Newkirk]

Probability	Dates for given probability and at temperature levels shown: 16° F.	20° F.	24° F.	28° F.	32° F.
Spring:					
1 year in 10, later than	March 21	April 1	April 8	April 10	April 27
2 years in 10, later than	March 13	March 24	April 2	April 5	April 21
5 years in 10, later than	February 27	March 11	March 20	March 27	April 10
Fall:					
1 year in 10, earlier than	November 22	November 8	November 4	October 23	October 17
2 years in 10, earlier than	November 29	November 16	November 9	October 29	October 21
5 years in 10, earlier than	December 14	November 30	November 19	November 8	October 29

as much as 50 miles per hour can be expected as cold fronts briskly pass, and winds occasionally reach 80 miles per hour in squalls and severe thunderstorms.

A total of 40 tornadoes have been observed in the county from 1875 through 1964. Three of these were severe enough to kill a few people, and in eight of them a large number of people were injured. In each of about 10 tornadoes, damage amounted to more than $100,000. Most of the property damage was in population centers, but farmsteads were also substantially damaged. Twenty people were killed and 280 were injured when the most severe tornado in the county crossed Blackwell on the night of May 25, 1955. Property damage amounted to slightly more than $8,000,000.

In 16 of the years from 1924 through 1964, 25 hailstorms were severe and produced hailstones of at least three-fourths inch in diameter. The threat of hail is from March through October, though 68 percent of the storms occur from April through June. The paths of nearly half of the hailstorms are more than 10 miles long.

Evaporation is a problem during the summer, when long periods of hot, dry weather are the result of the winds from the south and west. Annual evaporation from lakes in Kay County averages 57 inches, of which 71 percent is from May through October. Relative humidity averages from about 80 percent early in the morning to about 50 percent in the afternoon. The percentage of possible sunshine averages about 65 percent for the year and ranges from about 50 percent in winter to about 85 percent in summer.

Water Supply

The Chikaskia and Arkansas Rivers, two of the three major streams in the county, bring about 2,872,100 acre-feet of usable water to Kay County. The water in the Salt Fork Arkansas River is highly saline and is not usable.

Construction of the Kaw Reservoir has been authorized by Congress. This reservoir will be built about 9 miles east of Ponca City on the Arkansas River, above its confluence with the Salt Fork Arkansas River. Tentative plans provide for a storage capacity of 232,000 acre-feet of water. This water is expected to be of quality suitable for irrigation and for municipal and industrial uses.

Considerable ground water is known to exist along the Arkansas, Salt Fork Arkansas, and Chikaskia River valleys, but much of this water is held in a fine sand aquifer and is difficult to extract. Strongly flowing artesian water is at a depth of 60 to 75 feet in a small area about 2 miles northwest of Newkirk. In the rest of the county, the underground water is only in amounts needed for domestic uses.

Wells supply the water used for municipal purposes in Newkirk, Braman, and Tonkawa. The water used in Blackwell comes from the Chikaskia River. Water from Ponca Lake is used in Ponca City but also available is an auxiliary supply from wells dug into the bottom land along the Arkansas River.

Water for livestock is obtained mostly from farm ponds or reservoirs, but the rivers and smaller streams furnish some water for livestock on many farms and ranches. In the eastern part of the county, the ponds contain clean water and are larger and deeper than those in other parts. Windmills are not numerous in the county, but they pump a considerable amount of water for livestock.

Mineral Resources

From the widespread oilfields and gasfields in the county, oil, natural gas, butane, propane, gasoline, and other petroleum products are produced and contribute much to the economy. Search for new supplies of petroleum continues.

Limestone crops out in large amounts in the eastern part of Kay County. This limestone is quarried for building stone, crushed for concrete aggregate and for highway surfacing, and pulverized for farming purposes. The potential for future development is considerable.

Sand that is excellent for construction is obtained from bottom lands along the Arkansas and Chikaskia Rivers. Mixtures of sand, gravel, and clay suitable for surfacing roads are taken from a number of pits throughout the county.

Industries, Transportation, and Markets

The largest industrial plants in the county are those that process farm products, petroleum products, and mined metals. A meatpacking plant is at Ponca City, and a flour mill is at Blackwell. The grain elevators throughout the county have a total storage capacity of about 7,900,000 bushels.

The largest single plant in the county is the oil refinery at Ponca City. At Blackwell is another oil refinery and a large zinc smelter of the retort type at which many people are employed. At a quarry northeast of Ponca City, limestone is crushed for use in farming.

Major highways serving the county are Interstate Highway No. 35, U.S. Highways Nos. 77, 177, and 60, and State Route 11. County roads, most of them graveled and in good condition, follow section lines where possible. Most of the towns in the county are served by the main lines of four railroads and several branch lines. No place in the county is more than 10 miles from a rail shipping point. Petroleum and its products are carried by numerous pipelines. Ponca City has a municipal airport, and charter planes from Blackwell are available.

Primary markets for the crops and livestock products of the county are Oklahoma City and Tulsa in Oklahoma and Wichita in Kansas. Wichita is about 64 miles north of the northern boundary of Kay County; Tulsa is about 80 miles southeast of the extreme southeastern corner; and Oklahoma City is about 100 miles south of the southern boundary. Livestock auctions are held weekly at Tonkawa, Blackwell, and Newkirk, and a station for shipping cattle is at Hardy.

Agriculture

Most of Kay County, one of the leading agricultural counties in the State, is well suited to farming. In 1959, about 92 percent of the county, or 556,930 acres was in farms. Of this acreage, 300,519 acres was harvested cropland and 29,463 was pasture, including woodland pasture.

Since 1950, the number of farms has decreased, and the size of farms has increased. In 1959, there were 1,738 farms, compared to 2,346 in 1950. The average size of farms has increased from 243.3 acres in 1950 to 320.4 acres in 1959. In 1959, there were 56 farms of 1,000 acres or more.

Reports from farmers in the county in 1959 showed 912 cash-grain farms; 78 dairy farms; 239 livestock farms other than poultry and dairy, of which 30 are livestock ranches; 87 general farms; and 390 miscellaneous or unclassified farms.

The main farming enterprises are the production of crops and the raising of livestock. Wheat, barley, and grain sorghum are the main cash crops. Another cash crop is alfalfa, but alfalfa is also grown as a soil-improving crop and to supply hay for local livestock. The acreage of the principal crops for selected years is shown in table 9.

TABLE 9.—*Acreage of selected crops*

Crop	1949	1959
Small grain harvested:		
Wheat	235, 228	179, 456
Barley	843	36, 525
Oats	13, 101	35, 633
Rye	282	1, 300
Sorghum, all purposes	12, 533	19, 642
Corn, all purposes	9, 499	2, 079
Soybeans, all purposes	504	1, 234
Cotton	541	151
Hay crops:		
Alfalfa and alfalfa mixture	18, 904	12, 103
Native hay cut	8, 772	8, 260
Small grain cut for hay	722	1, 726

In 1959, the sale of livestock and livestock products in the county provided one-third of the farm income. Most of the livestock is raised in the eastern part of the county. In years of favorable moisture, many farmers in other parts of the county buy cattle to graze wheat pasture, or the farmers rent their wheat pasture to livestock operators. Table 10 shows the kinds and numbers of livestock on farms in the county in 1950 and 1959.

TABLE 10.—*Number of livestock*

Livestock	1950	1959
All cattle and calves	46, 215	46, 847
Milk cows	9, 197	3, 476
Hogs and pigs	13, 057	11, 818
Sheep and lambs	11, 911	13, 601
Horses and mules	2, 373	867
Chickens [1]	145, 905	93, 462

[1] More than 4 months old.

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Glossary

Aggregate. Many fine particles held in a single mass or cluster, such as a clod, crumb, block, or prism.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt. See also Texture.

Clay film. A thin coating of clay on the surface of a soil aggregate, or ped. Synonyms: clay coat, clay skin.

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Concretions. Grain, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent; soil does not hold together in a mass.

Friable.—When moist, soil crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, soil crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, soil is readily deformed by moderate pressure but can be pressed into a lump; forms a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, soil adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, soil is moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, soil breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle soil; little affected by moistening.

Cover crop. A close-growing crop grown primarily to improve and to protect the soil between periods of regular crop production; or a crop grown between trees and vines in orchards and vineyards.

Diversion. A ridge of earth, generally a terrace, that is built to divert runoff from its natural course and, thus, to protect areas downslope from the effects of such runoff.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes and that differs in one or more ways from adjacent horizons.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers of material.

Internal drainage. The downward movement of water through the soil profile. The rate of movement is determined by the texture, structure, and other characteristics of the soil profile and underlying layers, and by the height of the water table, either permanent or perched. Relative terms for expressing internal drainage are *none, very slow, slow, medium, rapid,* and *very rapid.*

Leaching. The removal of soluble materials from soils or other materials by percolating water.

Legume. A member of the widely distributed *leguminosae* family. Includes many valuable forage species, such as peas, beans, peanuts, clover, alfalfa, sweetclover, lespedeza, vetch, and kudzu. Practically all legumes are nitrogen-fixing plants, and many of the herbaceous species are used as cover and green-manure crops.

Mottled. Irregular markings or spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *Fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Organic matter. A general term for plant and animal material, in or on the soil, in all states of decomposition. Readily decomposed organic matter is often distinguished from the more stable forms that are past the state of rapid decomposition.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Permeability, soil. The quality of a soil horizon that enables water or air to move through it. Terms to describe permeability and the equivalent percolation rates in inches per hour are as follows: *Very slow*—less than 0.05, *slow*—0.05 to 0.20, *moderately slow*—0.20 to 0.80, *moderate*—0.80 to 2.50, *moderately rapid*—2.50 to 5.00, *rapid*—5.00 to 10.00 and *very rapid*—over 10.00.

Plowpan. A compacted layer formed in the soil immediately below the plowed layer.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material. See Horizon, soil.

Range. Land, that, for the most part, produces native plants suitable for grazing by livestock; includes land on which there are some forest trees.

Reaction. The degree of acidity or alkalinity of a soil expressed in pH values. The corresponding words used for ranges in pH are—

	pH
Extremely acid	Below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 millimeter to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay. See also Texture.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay. See also Texture.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular. Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Stubble mulching. Stubble or other crop residues left on the soil, or partly worked into the soil, to provide protection from wind and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Substratum. Any layer beneath the solum, or true soil; the C or R horizon.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surplus runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so that they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea. Stream terraces are frequently called *second bottoms,* as contrasted to *flood plains,* and are seldom subject to overflow.

Texture. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportions of fine particles are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine." See also Sand, Silt, and Clay.

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Water-holding capacity. The capacity of a soil to hold water. Some of this water is held by a soil and is not available to plants.

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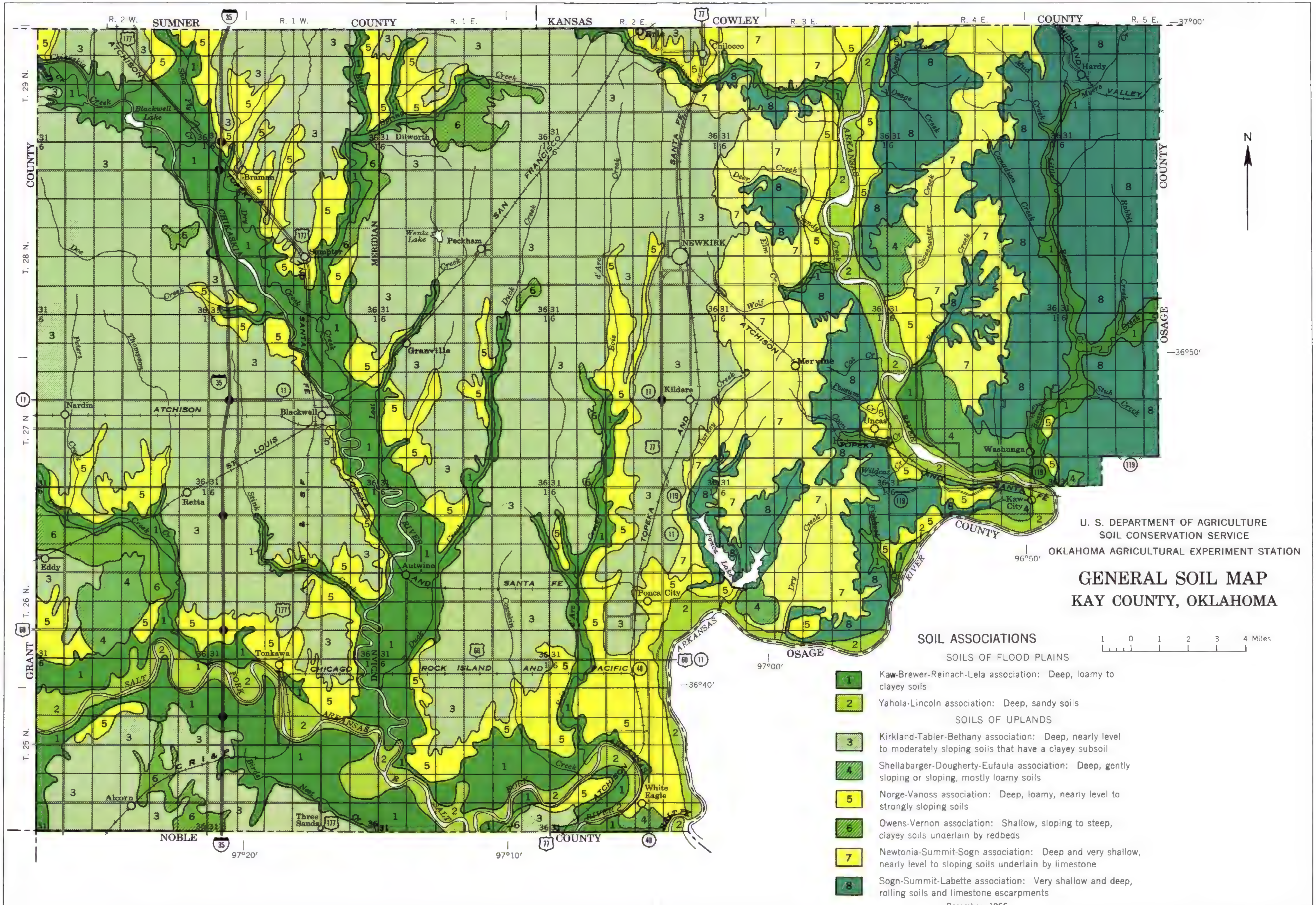
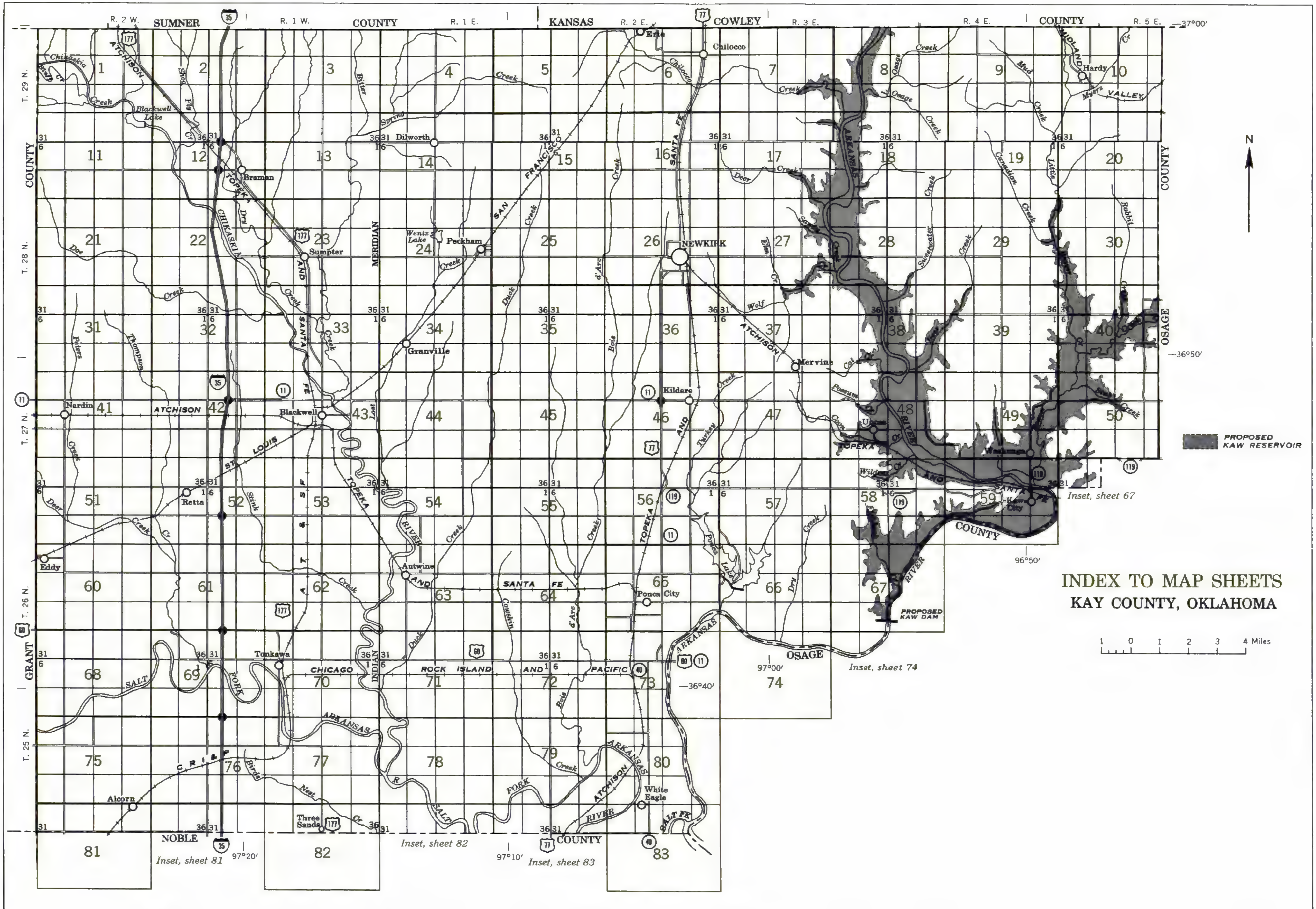

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
OKLAHOMA AGRICULTURAL EXPERIMENT STATION
GENERAL SOIL MAP
KAY COUNTY, OKLAHOMA
SOIL ASSOCIATIONS
SOILS OF FLOOD PLAINS
1 Kaw-Brewer-Reinach-Lela association: Deep, loamy to clayey soils
2 Yahola-Lincoln association: Deep, sandy soils
SOILS OF UPLANDS
3 Kirkland-Tabler-Bethany association: Deep, nearly level to moderately sloping soils that have a clayey subsoil
4 Shellabarger-Dougherty-Eufaula association: Deep, gently sloping or sloping, mostly loamy soils
5 Norge-Vanoss association: Deep, loamy, nearly level to strongly sloping soils
6 Owens-Vernon association: Shallow, sloping to steep, clayey soils underlain by redbeds
7 Newtonia-Summit-Sogn association: Deep and very shallow, nearly level to sloping soils underlain by limestone
8 Sogn-Summit-Labette association: Very shallow and deep, rolling soils and limestone escarpments
December 1966
1 0 1 2 3 4 Miles
N
SUMNER COUNTY KANSAS COWLEY COUNTY
GRANT COUNTY
NOBLE COUNTY
OSAGE COUNTY
R. 2 W.
R. 1 W.
R. 1 E.
R. 2 E.
R. 3 E.
R. 4 E.
R. 5 E.
T. 29 N.
T. 28 N.
T. 27 N.
T. 26 N.
T. 25 N.
37°00′
36°50′
36°40′
97°20′
97°10′
97°00′
96°50′
Blackwell
Ponca City
Newkirk
Tonkawa
Kildare
Braman
Chilocco
Hardy
Dilworth
Peckham
Granville
Nardin
Retta
Eddy
Autwine
Alcorn
Three Sands
White Eagle
Uncas
Washunga
Kaw City
Mervine
Sumpter
Wentz Lake
Blackwell Lake
Ponca Lake
ARKANSAS RIVER
SALT FORK
CHIKASKIA
ATCHISON
SANTA FE
ST. LOUIS
SAN FRANCISCO
TOPEKA
CHICAGO ROCK ISLAND AND PACIFIC


INDEX TO MAP SHEETS
KAY COUNTY, OKLAHOMA
PROPOSED KAW RESERVOIR
PROPOSED KAW DAM
SUMNER COUNTY
KANSAS
COWLEY COUNTY
GRANT COUNTY
NOBLE COUNTY
OSAGE COUNTY
Inset, sheet 67
Inset, sheet 74
Inset, sheet 81
Inset, sheet 82
Inset, sheet 83
NEWKIRK
Blackwell
Ponca City
Tonkawa
Braman
Sumpter
Peckham
Dilworth
Granville
Nardin
Kildare
Mervine
Retta
Eddy
Autwine
Alcorn
Three Sands
White Eagle
Kaw City
Washunga
Uncas
Hardy
Chilocco
Erie
1 0 1 2 3 4 Miles

SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, if used, shows the slope. Most symbols without a slope letter are for nearly level soils, but some are for land types that have a considerable range of slope. A final number, 2, in the symbol shows that the soil is eroded.

SYMBOL	NAME
BeA	Bethany silt loam, 0 to 1 percent slopes
Bk	Breaks–Alluvial land complex
Bm	Brewer silty clay loam
Br	Broken alluvial land
Ca	Carr fine sandy loam
CuB	Carwile–Pratt complex, undulating
Dc	Dale clay loam
Ds	Dale silt loam
DxB	Dougherty–Eufaula complex, 0 to 3 percent slopes
DxC	Dougherty–Eufaula complex, 3 to 8 percent slopes
Es	Eroded clayey land
Et	Eroded loamy land
Hu	Humbarger loam
Ka	Kaw silt loam
Kc	Kaw silty clay loam
KnB	Kirkland silt loam, 1 to 3 percent slopes
KrC2	Kirkland–Renfrow complex, 2 to 5 percent slopes, eroded
LaD	Labette clay loam, 5 to 8 percent slopes
LbC2	Labette–Slickspots complex, 3 to 5 percent slopes, eroded
Lc	Lela clay
Le	Lela–Slickspots complex
Lm	Lincoln soils
Lo	Loamy broken land
MaA	McLain silt loam
Mb	McLain silty clay loam
Mc	Miller clay
NeA	Newtonia silt loam, 0 to 1 percent slopes
NeB	Newtonia silt loam, 1 to 3 percent slopes
NeC	Newtonia silt loam, 3 to 5 percent slopes
NnC2	Newtonia clay loam, 3 to 5 percent slopes, eroded
NoA	Norge loam, 0 to 1 percent slopes
NoB	Norge loam, 1 to 3 percent slopes
NoC	Norge loam, 3 to 5 percent slopes
NoC2	Norge loam, 3 to 5 percent slopes, eroded
NoD	Norge loam, 5 to 8 percent slopes
NoD2	Norge loam, 5 to 8 percent slopes, eroded
NxC	Norge–Albion complex, 3 to 5 percent slopes
Od	Oil–waste land
OwE	Owens clay, 3 to 12 percent slopes
Pf	Port soils, frequently flooded
Ps	Port silt loam
PtC	Pratt loamy fine sand, hummocky
RcA	Reinach loam, 0 to 1 percent slopes
RcD	Reinach loam, 3 to 8 percent slopes
RkC	Renfrow–Kirkland silt loams, 3 to 5 percent slopes
Sa	Sand dunes, Lincoln material
SnB	Shellabarger fine sandy loam, 1 to 3 percent slopes
ShC	Shellabarger fine sandy loam, 3 to 5 percent slopes
ShD	Shellabarger fine sandy loam, 5 to 8 percent slopes
SnB	Sogn soils, 1 to 3 percent slopes
SsF	Sogn–Summit complex, 5 to 20 percent slopes
SuB	Summit silty clay loam, 1 to 3 percent slopes
SuC	Summit silty clay loam, 3 to 5 percent slopes
SyC2	Summit silty clay, 3 to 5 percent slopes, eroded
TaA	Tabler silt loam, 0 to 1 percent slopes
VaA	Vanoss silt loam, 0 to 1 percent slopes
VaB	Vanoss silt loam, 1 to 3 percent slopes
VaC	Vanoss silt loam, 3 to 5 percent slopes
VaD	Vanoss silt loam, 5 to 8 percent slopes
VeC	Vernon clay loam, 3 to 5 percent slopes
VsE	Vernon soils, 5 to 12 percent slopes
Wa	Waurika silt loam
Ya	Yahola fine sandy loam
Yf	Yahola loamy fine sand

CONVENTIONAL SIGNS

WORKS AND STRUCTURES

Highways and roads
- Dual
- Good motor
- Poor motor
- Trail

Highway markers
- National Interstate
- U. S.
- State or county

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail, foot
- Railroad
- Ferry (FY)
- Ford
- Grade
- R. R. over
- R. R. under
- Tunnel

Buildings
- School
- Church
- Station

Mines and Quarries

Mine dump

Pits, gravel, shale, sandstone

Power line

Pipeline

Cemetery

Dams

Levee

Tanks

Well, oil or gas

BOUNDARIES

- National or state
- County
- Township or range, U. S.
- Section line, corner, U. S.
- Reservation
- Land grant
- Small park, cemetery, airport

DRAINAGE

Streams, double-line
- Perennial
- Intermittent

Streams, single-line
- Perennial
- Intermittent
  - Crossable with tillage implements
  - Not crossable with tillage implements
- Unclassified

Canals and ditches (CANAL)

Lakes and ponds
- Perennial
- Intermittent

Wells, water (flowing)

Spring

Marsh or swamp

Wet spot

Alluvial fan

Drainage end

RELIEF

Escarpments
- Bedrock
- Other

Prominent peak

Depressions (Large, Small)
- Crossable with tillage implements
- Not crossable with tillage implements
- Contains water most of the time

SOIL SURVEY DATA

- Soil boundary and symbol (Dx)
- Gravel
- Stony, very stony
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo, slick, or scabby spot
- Made land
- Severely eroded spot
- Blowout, wind erosion
- Gully

PROPOSED KAW RESERVOIR

Area of normal or conservation pool, below elevation 1,010.0 feet, is overprinted with fine blue dots. The 1,010.0 ft. contour is shown as a solid black line.

Area subject to periodic inundation (flood control), between elevations 1,010.0 and 1,044.5 feet is overprinted with fine diagonal blue lines. The 1,044.5 ft. contour is shown as a dashed black line.

Soil map constructed 1962 by Cartographic Division, Soil Conservation Service, USDA, from 1961 aerial photographs. Controlled mosaic based on Oklahoma plane coordinate system, north zone, Lambert conformal conic projection, 1927 North American datum.

GUIDE TO MAPPING UNITS

[To obtain a full description of a mapping unit, read both the description of the mapping unit and the description of the soil series to which the mapping unit belongs.

[See table 1, page 9, for the approximate acreage and proportionate extent of the soils and table 2, page 42, for the predicted average yields per acre. For a discussion of woodland suitability groups, see pages 47 and 48. For information about engineering, see the subsection "Use of Soils in Engineering," beginning on page 50]

Map symbol	Mapping unit	Described on page	Capability unit		Range site	
			Symbol	Page	Name	Page
~~Ba~~ BeA	Bethany silt loam, 0 to 1 percent slopes	10	I-2	33	Loamy Prairie	46
Bk	Breaks-Alluvial land complex	10				
	Breaks	--	VIe-4	40	Loamy Prairie	46
	Alluvial land	--	VIe-4	40	Loamy Bottom-land	44
Bm	Brewer silty clay loam	11	I-1	33	Heavy Bottom-land	44
Br	Broken alluvial land	11	Vw-1	39	Loamy Bottom-land	45
Ca	Carr fine sandy loam	11	IIw-3	35	Loamy Bottom-land	45
CuB	Carwile-Pratt complex, undulating	12				
	Carwile soil	--	IIw-1	34	Sandy Prairie	47
	Pratt soil	--	IIw-1	34	Deep Sand	43
Dc	Dale clay loam	12	I-1	33	Loamy Bottom-land	45
Ds	Dale silt loam	12	I-1	33	Loamy Bottom-land	45
DxB	Dougherty-Eufaula complex, 0 to 3 percent slopes	13	IIIe-5	36	Deep Sand Savannah	43
DxC	Dougherty-Eufaula complex, 3 to 8 percent slopes	13	IVe-6	38	Deep Sand Savannah	43
Es	Eroded clayey land	13	VIe-1	39	Eroded Clay	44
Et	Eroded loamy land	14	VIe-2	40	Loamy Prairie	46
Hu	Humbarger loam	14	IIw-2	35	Loamy Bottom-land	45
Ka	Kaw silt loam	15	IIw-2	35	Loamy Bottom-land	45
Kc	Kaw silty clay loam	15	IIw-2	35	Loamy Bottom-land	45
KnB	Kirkland silt loam, 1 to 3 percent slopes	16	IIIe-1	35	Claypan Prairie	43
KrC2	Kirkland-Renfrow complex, 2 to 5 percent slopes, eroded	16	IVe-2	37	Claypan Prairie	43
LaD	Labette clay loam, 5 to 8 percent slopes	17	IVe-3	37	Loamy Prairie	46
LbC2	Labette-Slickspots complex, 3 to 5 percent slopes, eroded	17				
	Labette soil	--	IVs-2	39	Loamy Prairie	46
	Slickspots	--	IVs-2	39	Slickspot	47
Lc	Lela clay	18	IIIw-1	37	Heavy Bottom-land	44
Le	Lela-Slickspots complex	18				
	Lela soil	--	IVs-1	39	Heavy Bottom-land	44
	Slickspots	--	IVs-1	39	Alkali Bottom-land	43
Lm	Lincoln soils 1/	18	Vw-2	39	Sandy Bottom-land	46
Lo	Loamy broken land	18	VIe-3	40	Loamy Prairie	46
MaA	McLain silt loam	19	I-1	33	Loamy Bottom-land	45
Mb	McLain silty clay loam	19	I-1	33	Loamy Bottom-land	45
Mc	Miller clay	19	IIIw-1	37	Heavy Bottom-land	44
NeA	Newtonia silt loam, 0 to 1 percent slopes	20	I-2	33	Loamy Prairie	46
NeB	Newtonia silt loam, 1 to 3 percent slopes	20	IIe-1	33	Loamy Prairie	46
NeC	Newtonia silt loam, 3 to 5 percent slopes	20	IIIe-2	36	Loamy Prairie	46
NnC2	Newtonia clay loam, 3 to 5 percent slopes, eroded	20	IIIe-3	36	Loamy Prairie	46
NoA	Norge loam, 0 to 1 percent slopes	21	I-2	33	Loamy Prairie	46
NoB	Norge loam, 1 to 3 percent slopes	21	IIe-1	33	Loamy Prairie	46
NoC	Norge loam, 3 to 5 percent slopes	21	IIIe-2	36	Loamy Prairie	46
NoC2	Norge loam, 3 to 5 percent slopes, eroded	21	IIIe-3	36	Loamy Prairie	46
NoD	Norge loam, 5 to 8 percent slopes	21	IVe-3	37	Loamy Prairie	46
NoD2	Norge loam, 5 to 8 percent slopes, eroded	22	IVe-4	37	Loamy Prairie	46
NxC	Norge-Albion complex, 3 to 5 percent slopes	22				
	Norge soil	--	IIIe-2	36	Loamy Prairie	46
	Albion soil	--	IIIe-2	36	Sandy Prairie	47
Od	Oil-waste land	22	VIIIs-1	41	------------	--
OwE	Owens clay, 3 to 12 percent slopes	23	VIe-5	40	Red Clay Prairie	46
Pf	Port soils, frequently flooded	23	Vw-2	39	Loamy Bottom-land	45
Ps	Port silt loam	23	IIw-2	35	Loamy Bottom-land	45
PtC	Pratt loamy fine sand, hummocky	24	IVe-6	38	Deep Sand	43
RcA	Reinach loam, 0 to 1 percent slopes	24	I-1	33	Loamy Bottom-land	45
RcD	Reinach loam, 3 to 8 percent slopes	24	IVe-8	38	Loamy Bottom-land	45
RkC	Renfrow-Kirkland silt loams, 3 to 5 percent slopes	25	IVe-7	38	Claypan Prairie	43
Sa	Sand dunes, Lincoln material	25	VIs-1	40	Dune	43
ShB	Shellabarger fine sandy loam, 1 to 3 percent slopes	26	IIe-2	33	Sandy Prairie	47
ShC	Shellabarger fine sandy loam, 3 to 5 percent slopes	26	IIIe-4	36	Sandy Prairie	47
ShD	Shellabarger fine sandy loam, 5 to 8 percent slopes	26	IVe-5	38	Sandy Prairie	47
SnB	Sogn soils, 1 to 3 percent slopes	26	VIIs-1	40	Very Shallow	47
SsF	Sogn-Summit complex, 5 to 20 percent slopes	27				
	Sogn soil	--	VIIs-1	40	Very Shallow	47
	Summit soil	--	VIIs-1	40	Loamy Prairie	46
SuB	Summit silty clay loam, 1 to 3 percent slopes	27	IIe-1	33	Loamy Prairie	46
SuC	Summit silty clay loam, 3 to 5 percent slopes	27	IIIe-2	36	Loamy Prairie	46
SyC2	Summit silty clay, 3 to 5 percent slopes, eroded	28	IIIe-3	36	Loamy Prairie	46
TaA	Tabler silt loam, 0 to 1 percent slopes	28	IIs-1	34	Claypan Prairie	43
VaA	Vanoss silt loam, 0 to 1 percent slopes	29	I-2	33	Loamy Prairie	46
VaB	Vanoss silt loam, 1 to 3 percent slopes	29	IIe-1	33	Loamy Prairie	46
VaC	Vanoss silt loam, 3 to 5 percent slopes	29	IIIe-2	36	Loamy Prairie	46
VaD	Vanoss silt loam, 5 to 8 percent slopes	29	IVe-3	39	Loamy Prairie	46
VeC	Vernon clay loam, 3 to 5 percent slopes	29	IVe-1	37	Red Clay Prairie	46
VsE	Vernon soils, 5 to 12 percent slopes	30	VIe-5	40	Red Clay Prairie	46
Wa	Waurika silt loam	31	IIs-2	34	Claypan Prairie	43
Ya	Yahola fine sandy loam	31	IIw-3	35	Loamy Bottom-land	45
Yf	Yahola loamy fine sand	31	IIIs-1	36	Sandy Bottom-land	46

1/ In later surveys, the soils in this series have been placed in the Crevasse series.

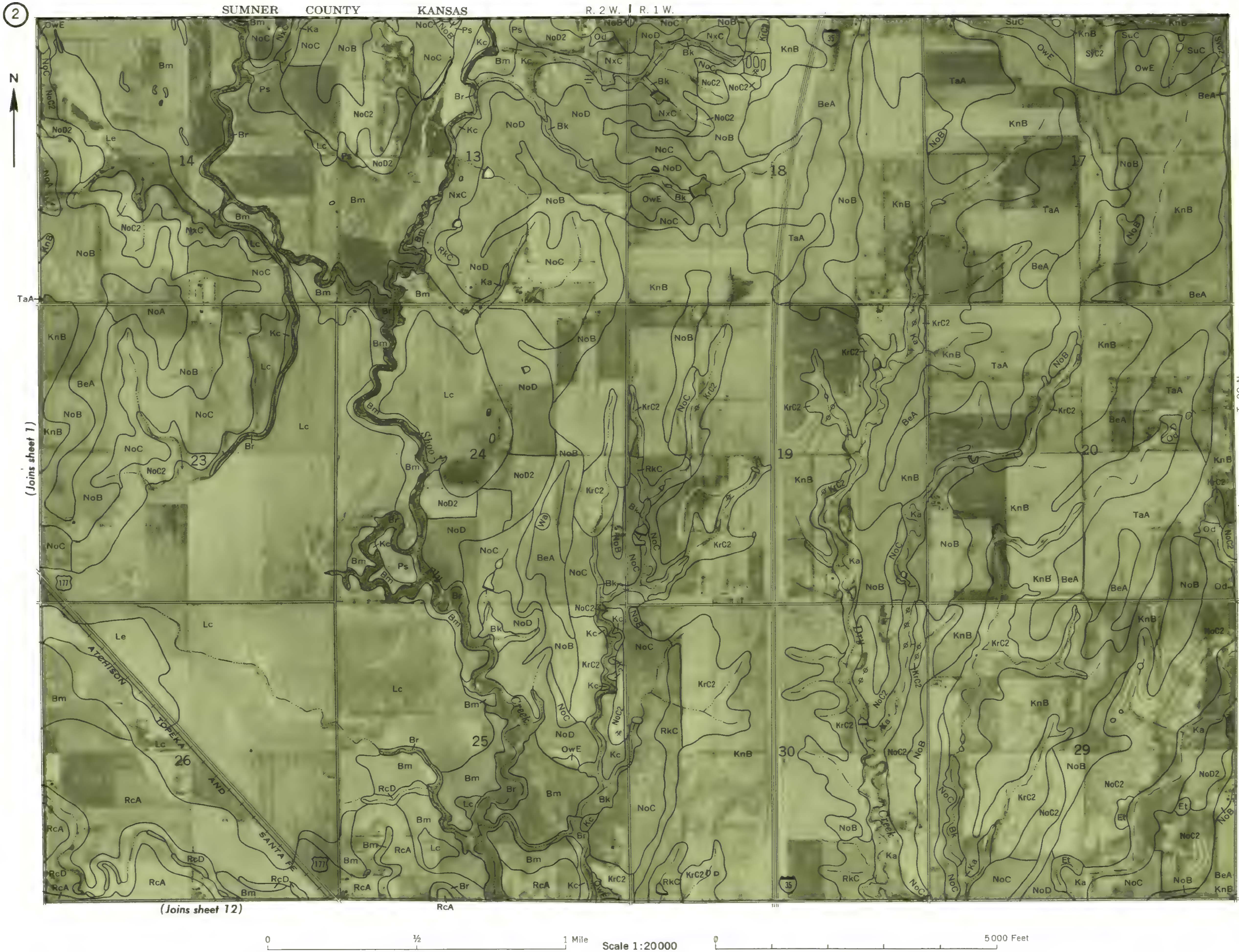
255-333 O - 67 (Face p. 88)

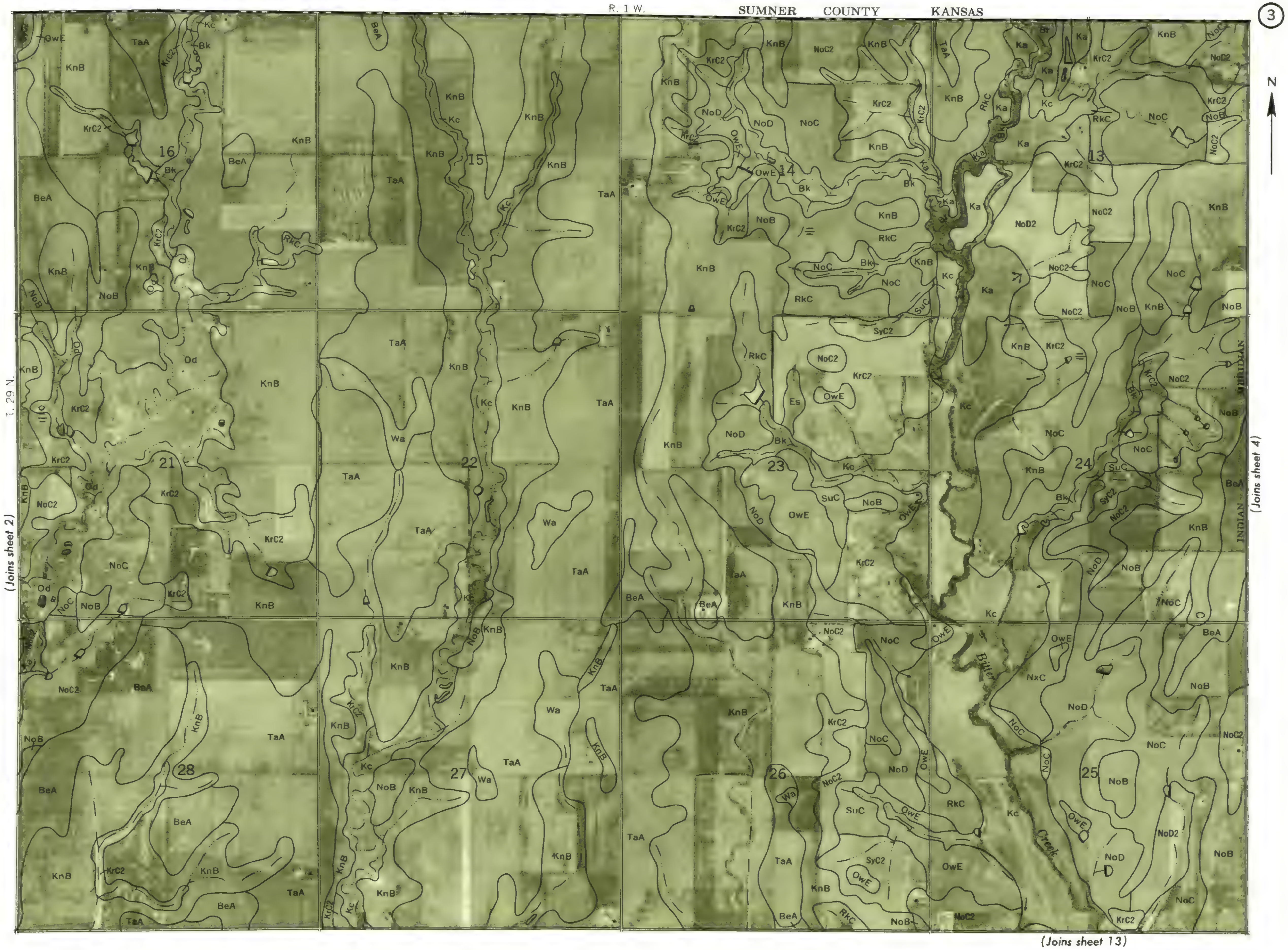
KAY COUNTY, OKLAHOMA — SHEET NUMBER 1

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 1


2
SUMNER COUNTY KANSAS
R. 2 W. | R. 1 W.
N
T. 29 N.
(Joins sheet 1)
(Joins sheet 3)
(Joins sheet 12)
ATCHISON TOPEKA AND SANTA FE
0 ½ 1 Mile
Scale 1:20000
0 5000 Feet

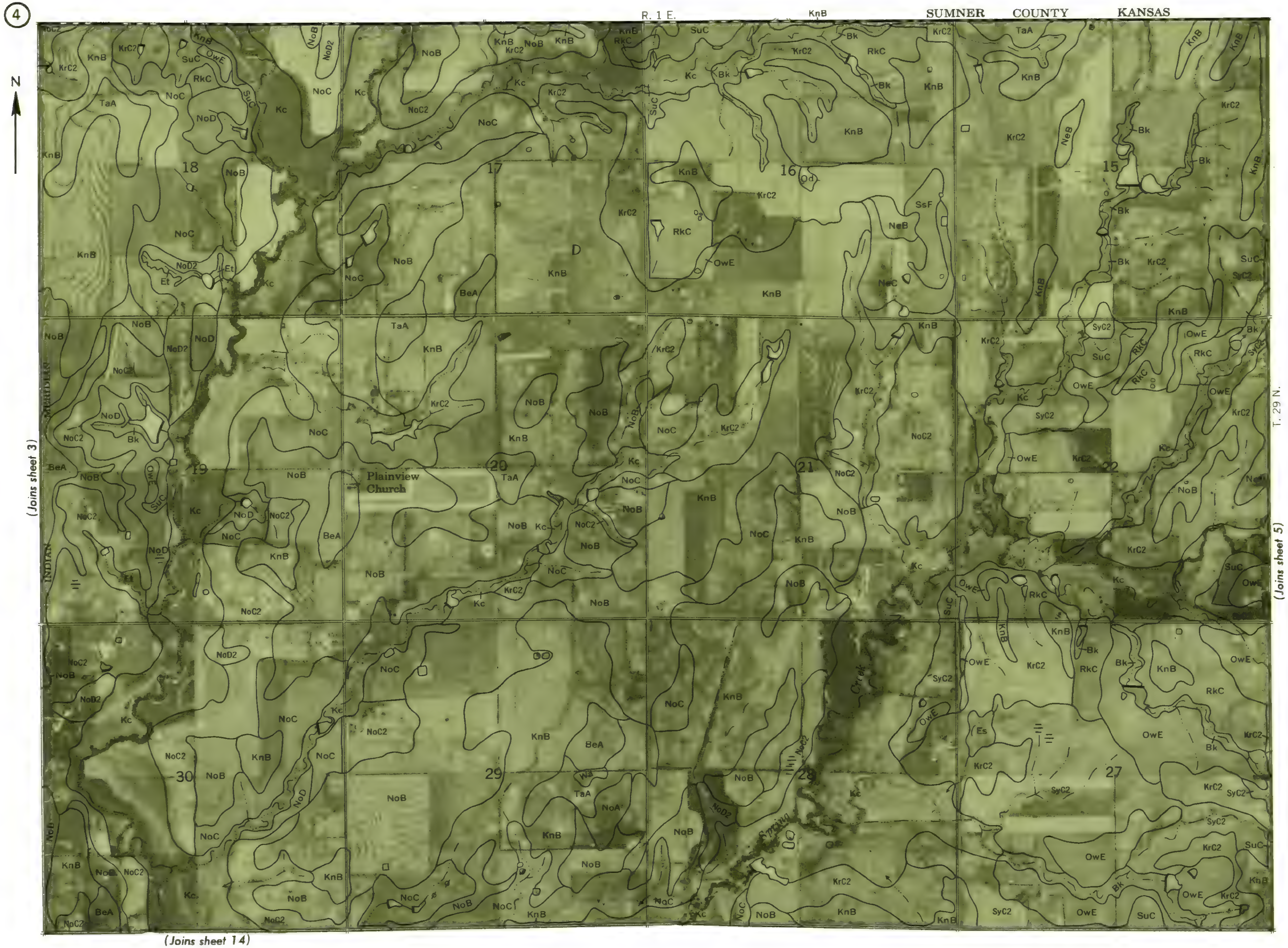


0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 3



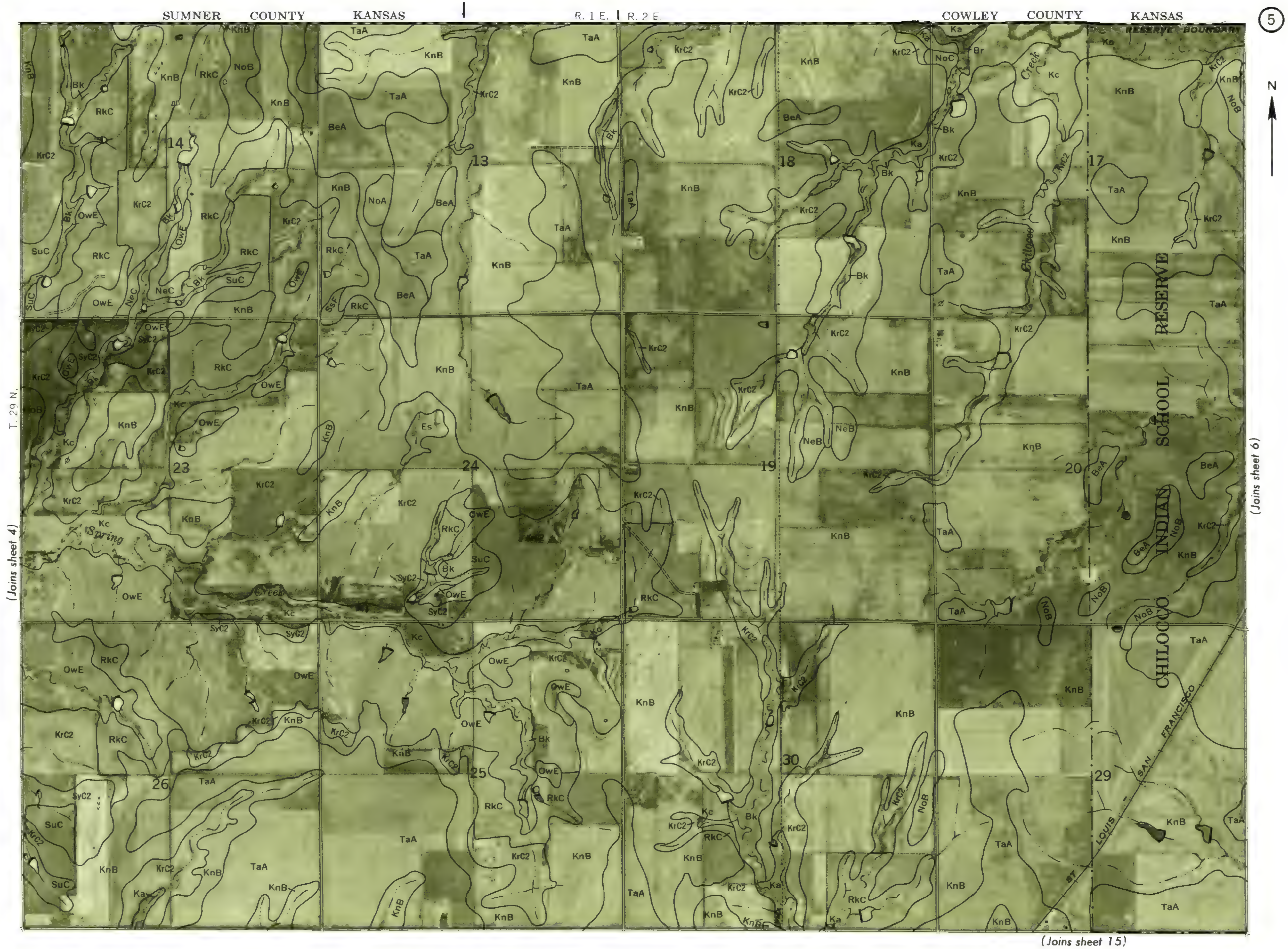
0 ½ 1 Mile Scale 1:20000 0 5000 Feet

KAY COUNTY, OKLAHOMA — SHEET NUMBER 5

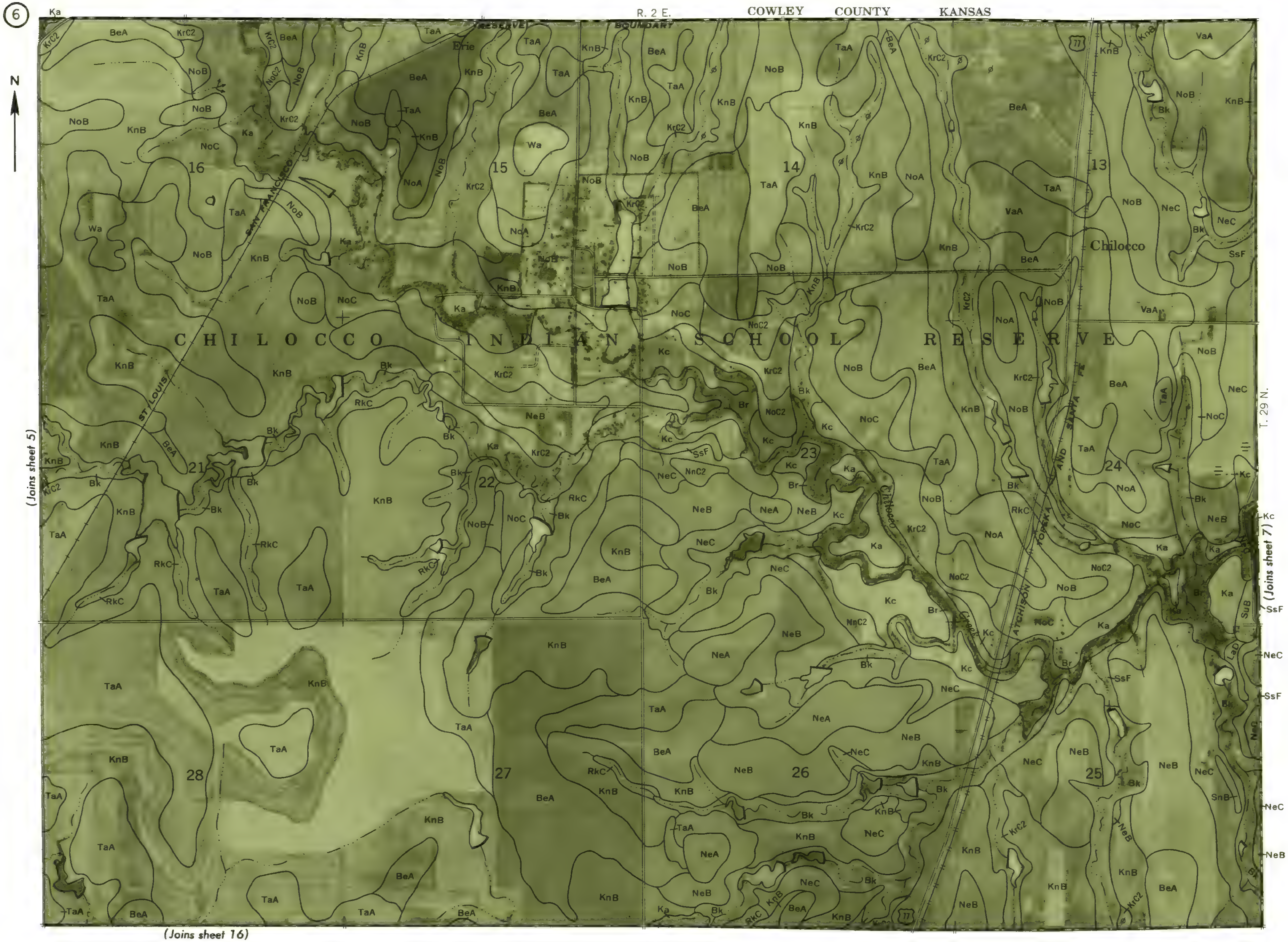
This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 5



0 ½ 1 Mile Scale 1:20000 0 5000 Feet



0 ½ 1 Mile Scale 1:20000 0 5000 Feet

7

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

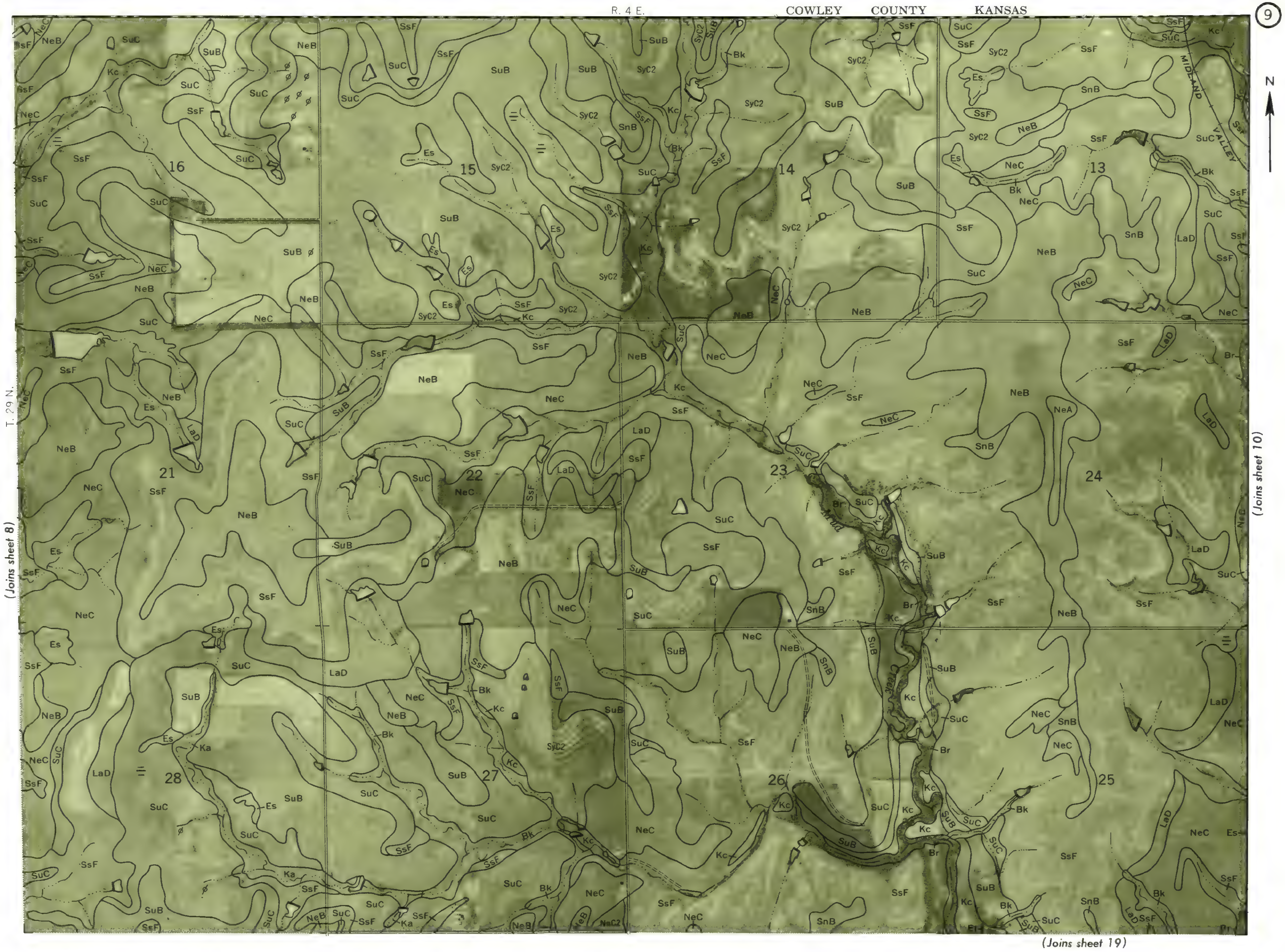
KAY COUNTY, OKLAHOMA NO. 7


8
N
R. 3 E.
R. 4 E.
COWLEY COUNTY KANSAS
T. 29 N.
(Joins sheet 7)
(Joins sheet 9)
(Joins sheet 18)
ARKANSAS
RIVER
Osage Creek
Chilocco Creek
0
½
1 Mile
Scale 1:20000
0
5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 9



0 ½ 1 Mile Scale 1:20000 0 5000 Feet


10
R. 5 E.
COWLEY COUNTY KANSAS
OSAGE COUNTY
T. 29 N.
(Joins sheet 9)
(Joins sheet 20)
Hardy
MIDLAND VALLEY
Myers Creek
0 ½ 1 Mile
Scale 1:20000
0 5000 Feet

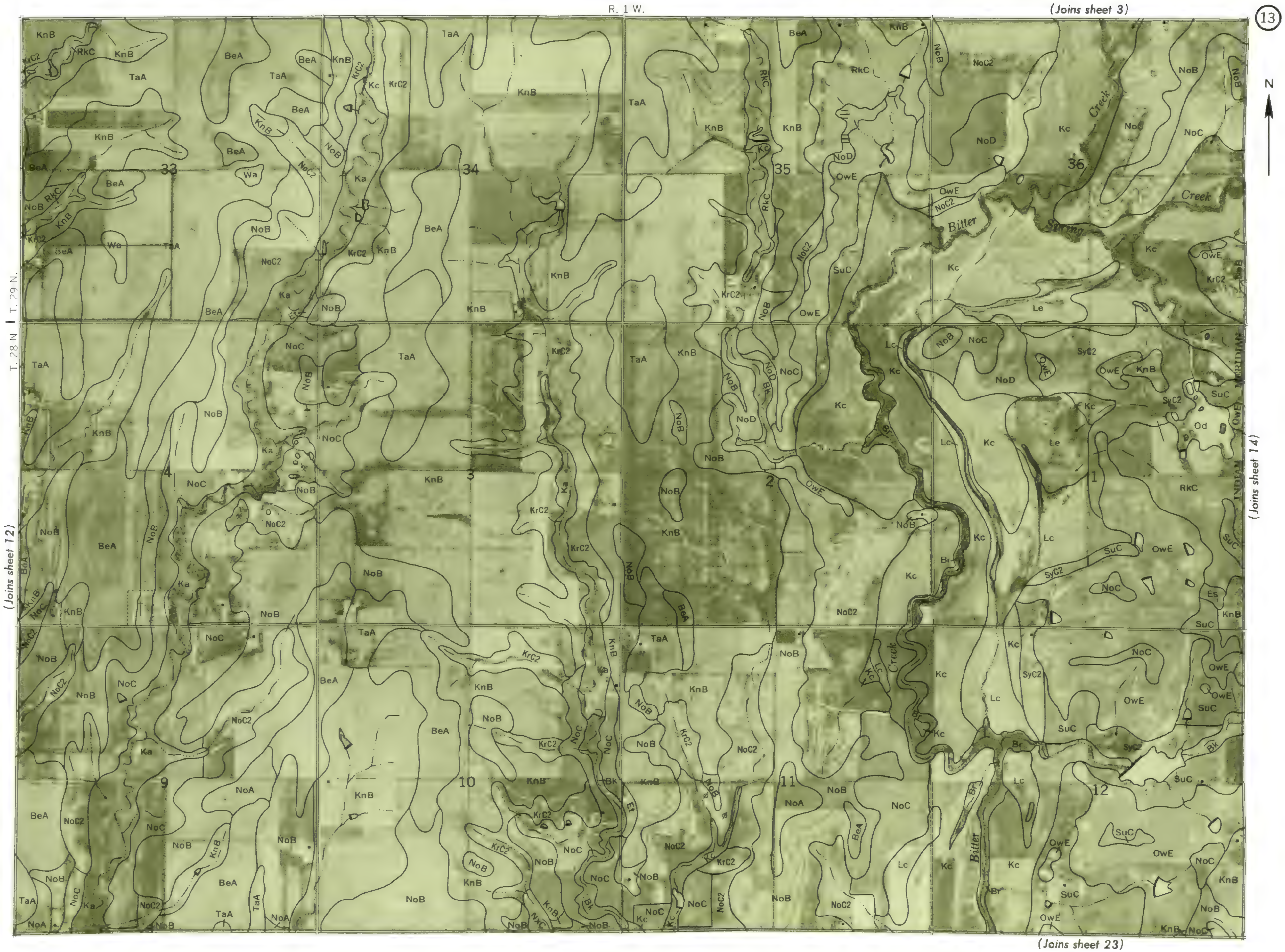
0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 11

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

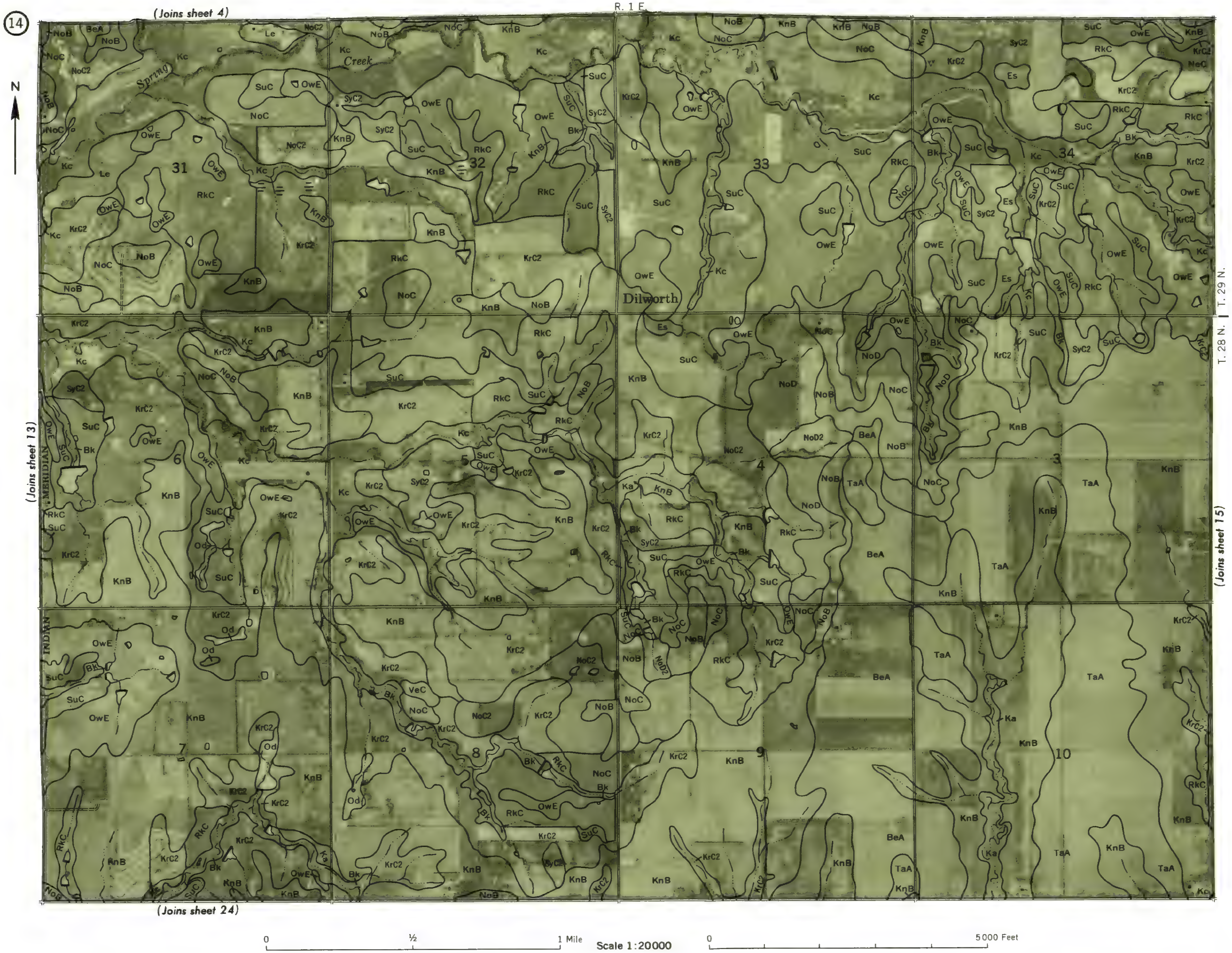


0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 13



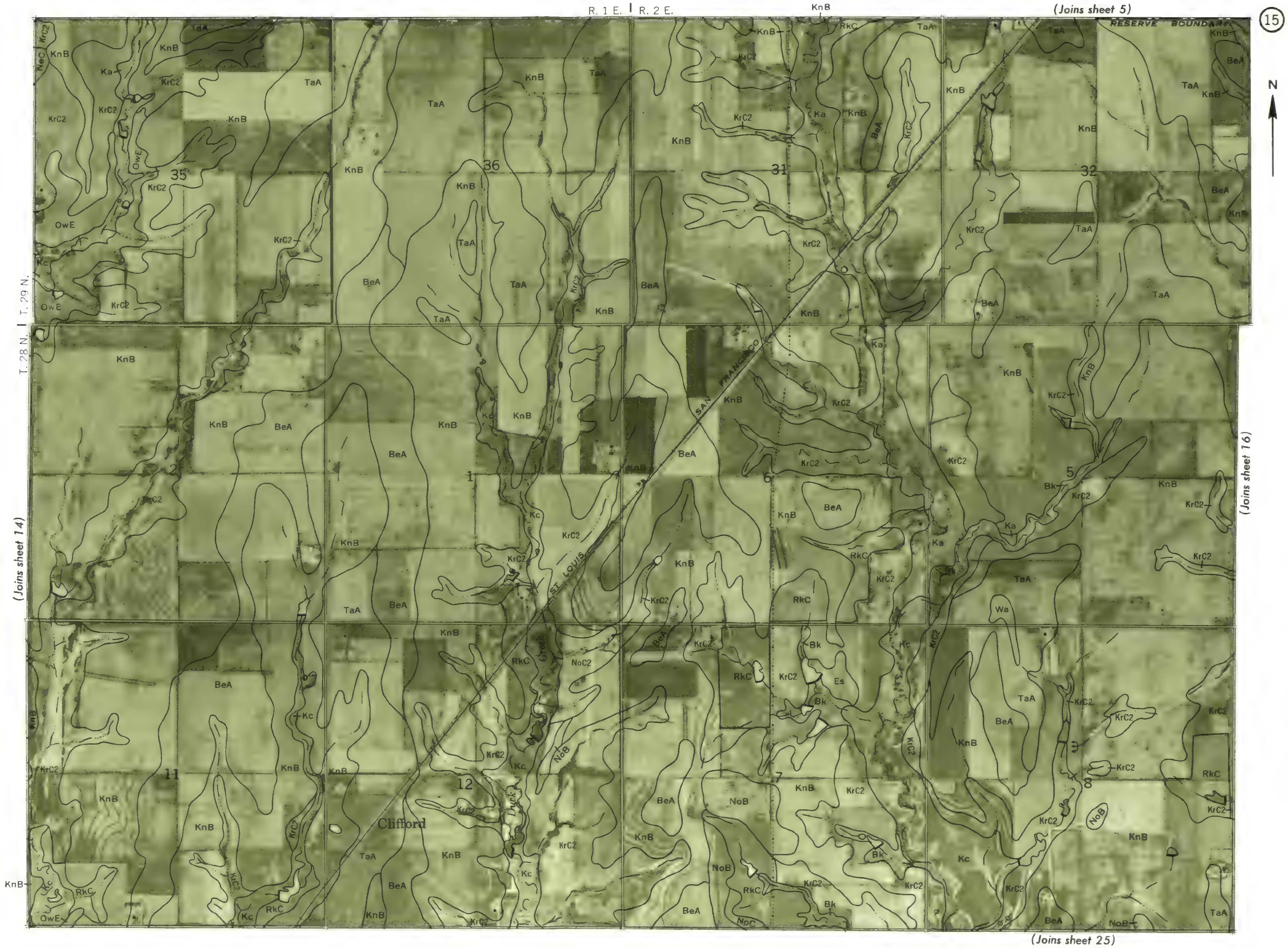
KAY COUNTY, OKLAHOMA NO. 14

KAY COUNTY, OKLAHOMA — SHEET NUMBER 15

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 15



0 ½ 1 Mile Scale 1:20000 0 5000 Feet

KAY COUNTY, OKLAHOMA — SHEET NUMBER 16

KAY COUNTY, OKLAHOMA NO. 16

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 17

18

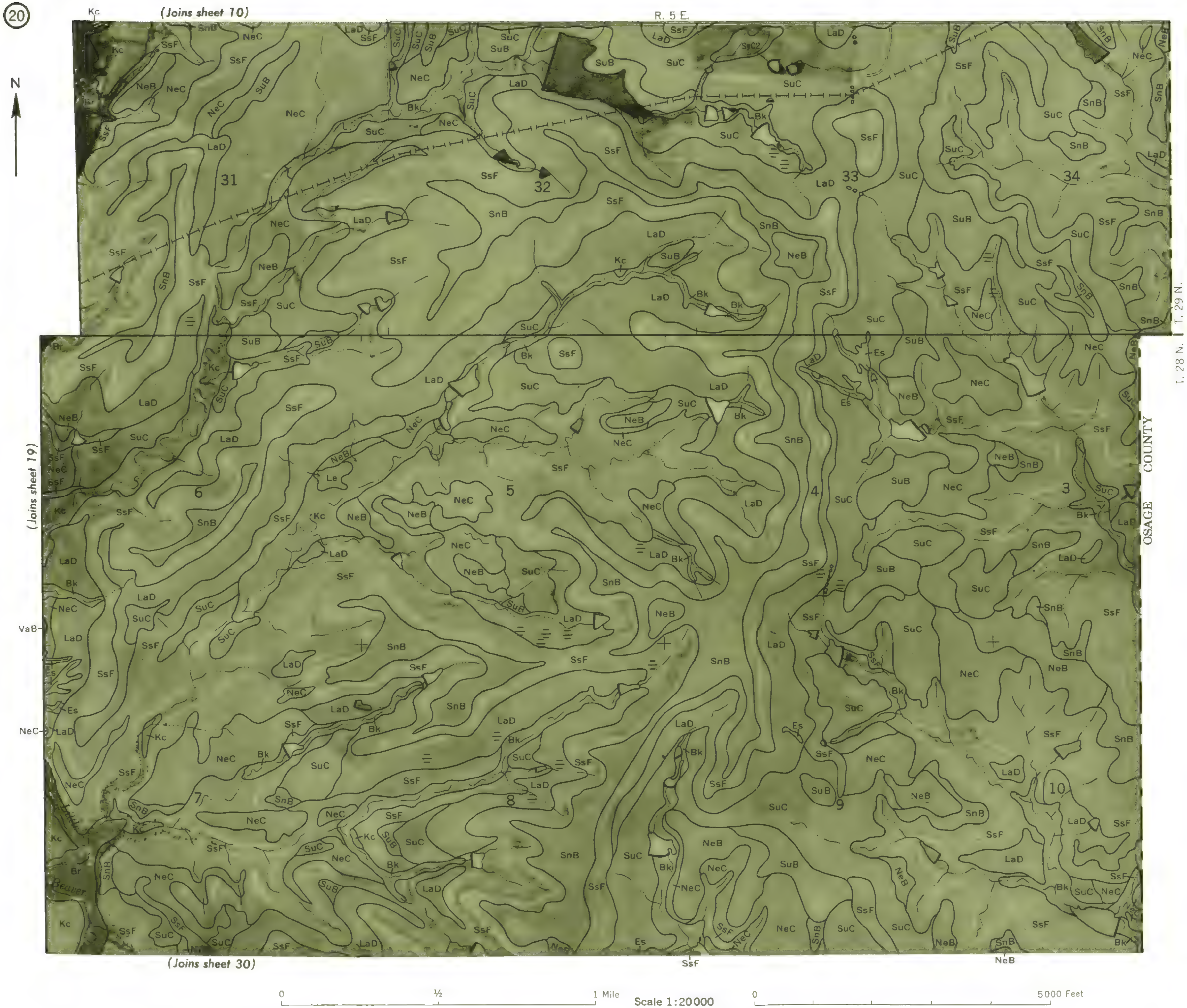
0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 19

0 ½ 1 Mile Scale 1:20000 0 5000 Feet


20
(Joins sheet 10)
R. 5 E.
N
(Joins sheet 19)
(Joins sheet 30)
T. 29 N.
T. 28 N.
OSAGE COUNTY
31
32
33
34
6
5
4
3
7
8
9
10
0
½
1 Mile
Scale 1:20000
0
5000 Feet

(Joins sheet 11)

(Joins sheet 31)

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 21


22
(Joins sheet 12)
R. 2 W.
R. 1 W.
(Joins sheet 21)
(Joins sheet 23)
T. 28 N.
(Joins sheet 32)
14
13
18
17
23
24
19
20
26
25
30
29
0
½
1 Mile
Scale 1:20000
0
5000 Feet

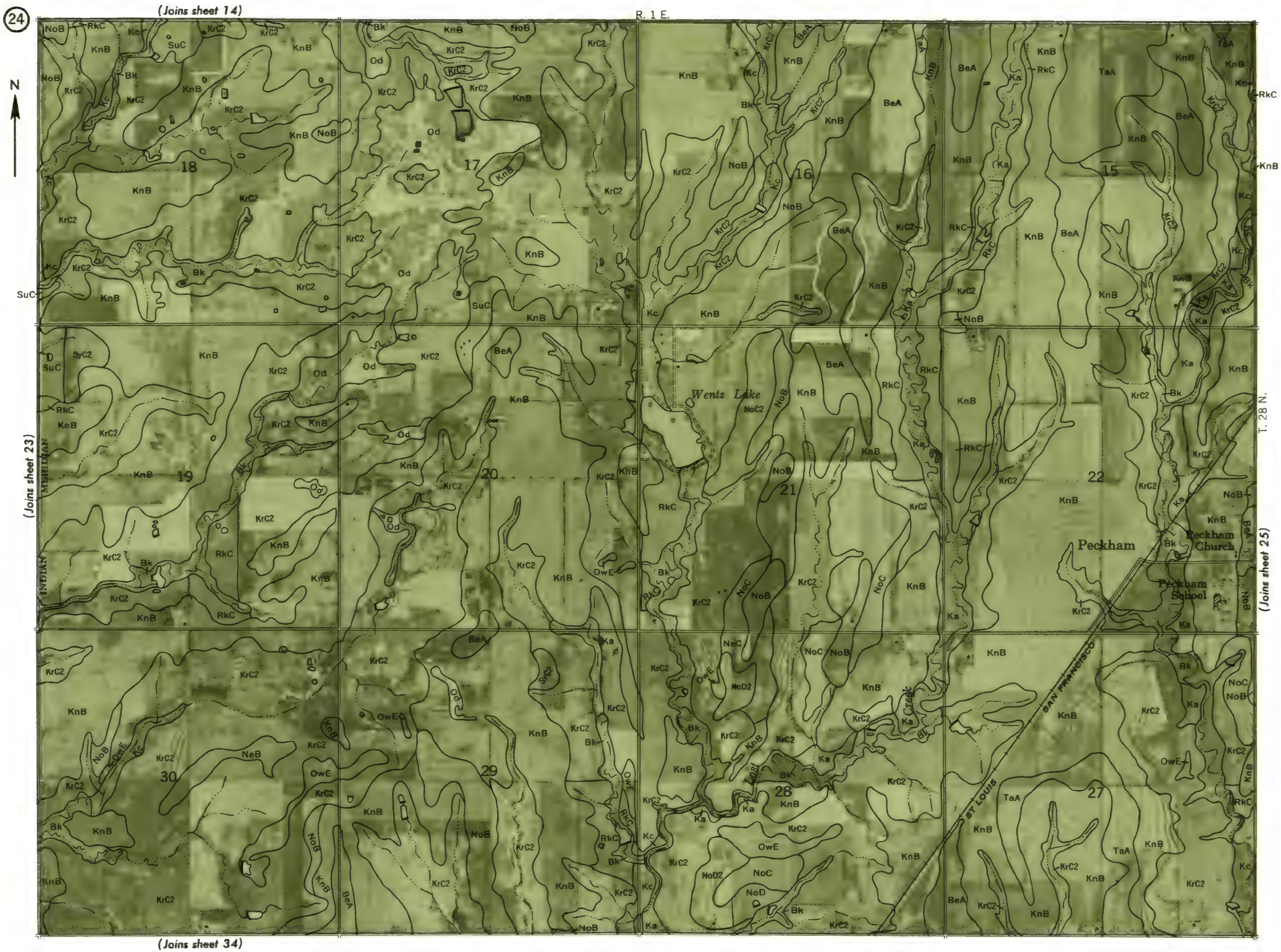
KAY COUNTY, OKLAHOMA — SHEET NUMBER 23

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

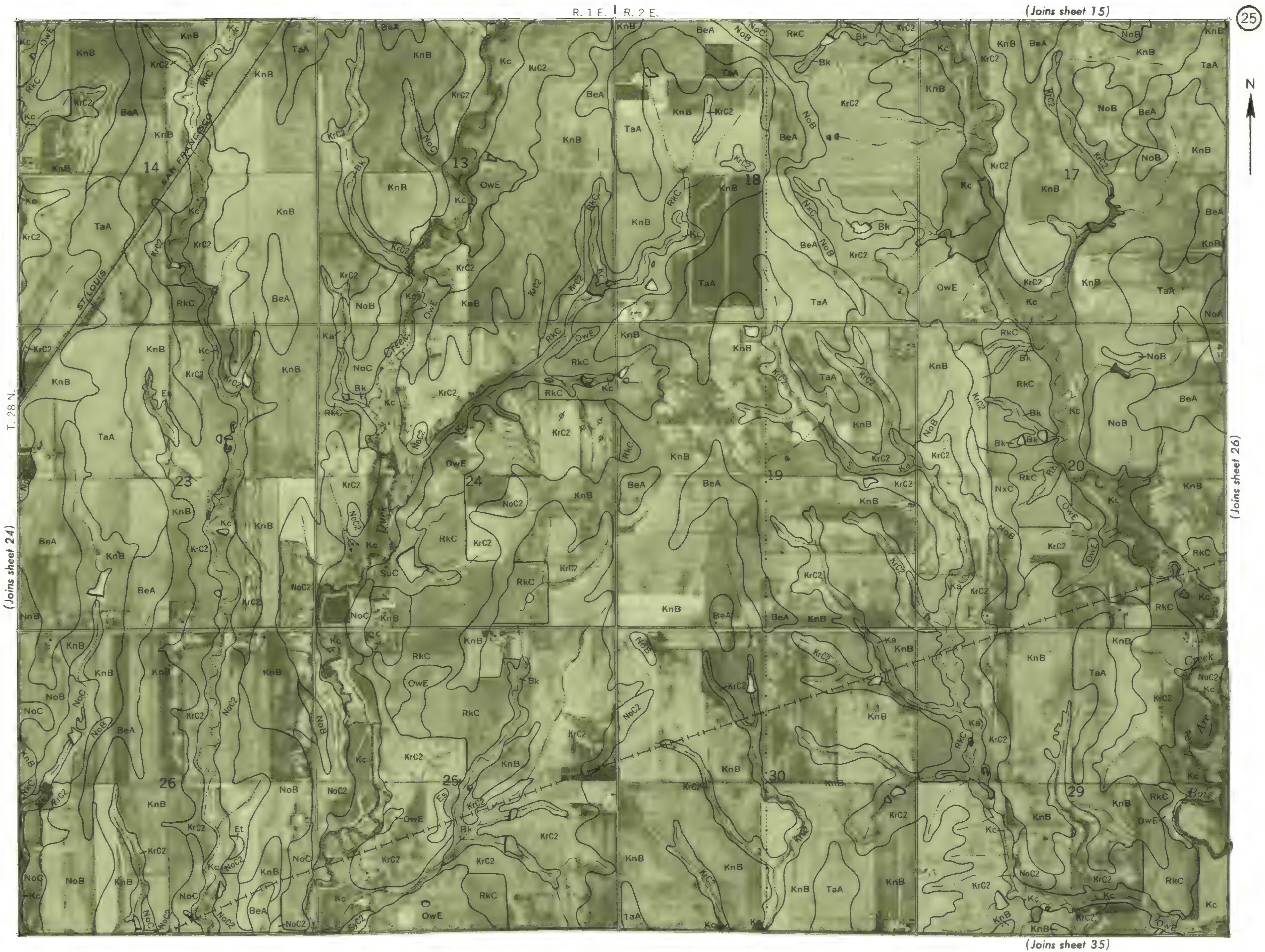
KAY COUNTY, OKLAHOMA NO. 23



0 ½ 1 Mile Scale 1:20000 0 5000 Feet

KAY COUNTY, OKLAHOMA NO. 24

KAY COUNTY, OKLAHOMA — SHEET NUMBER 25

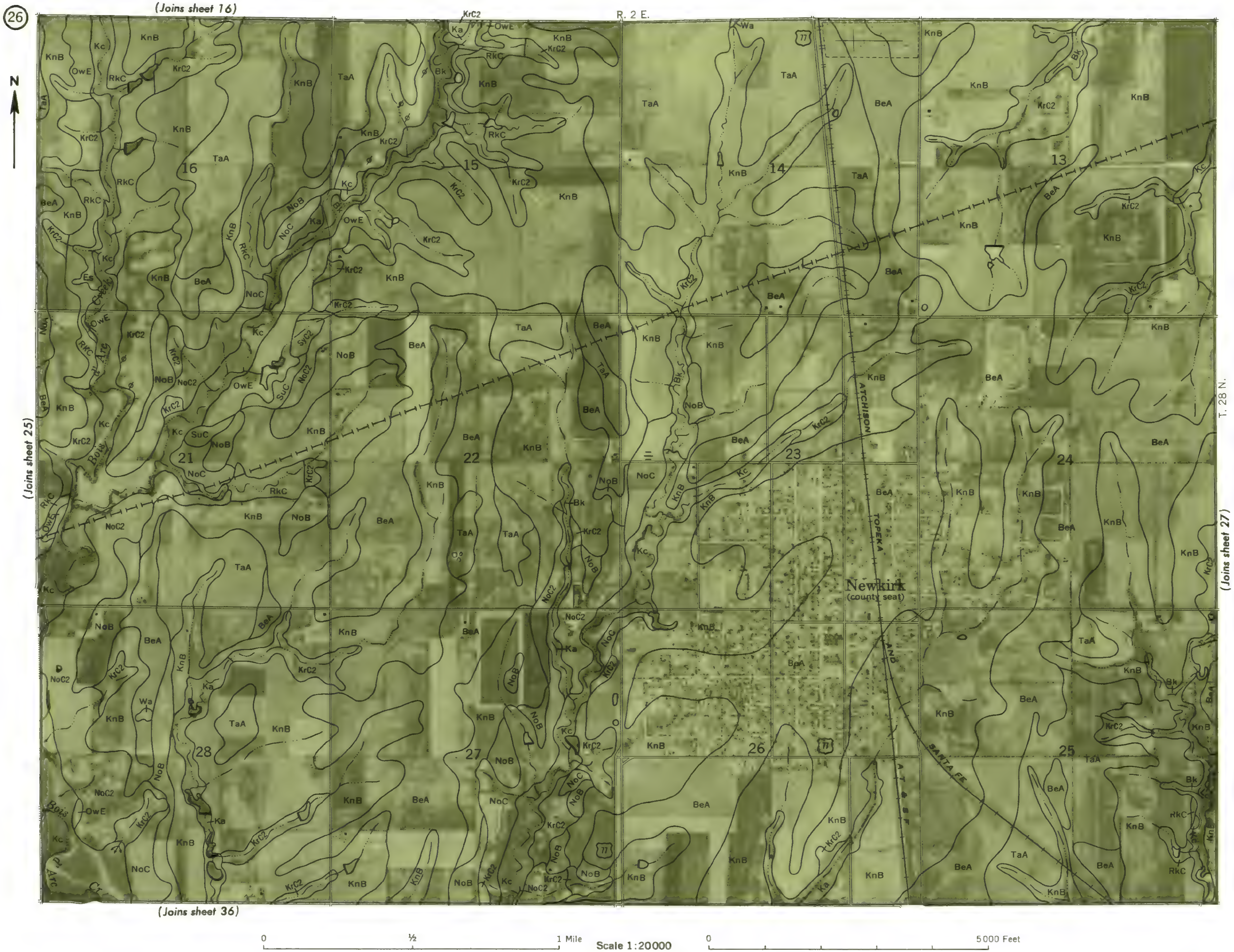


0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 25


26
(Joins sheet 16)
(Joins sheet 25)
(Joins sheet 27)
(Joins sheet 36)
N
R. 2 E.
T. 28 N.
Newkirk
(county seat)
ATCHISON
TOPEKA
AND
SANTA FE
AT & SF
Bois d' Arc Creek
16
15
14
13
21
22
23
24
28
27
26
25
KnB
TaA
BeA
KrC2
RkC
OwE
Kc
Ka
Bk
NoB
NoC
NoC2
SuC
Es
Wa
0
½
1 Mile
Scale 1:20000
0
5000 Feet

KAY COUNTY, OKLAHOMA — SHEET NUMBER 27

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

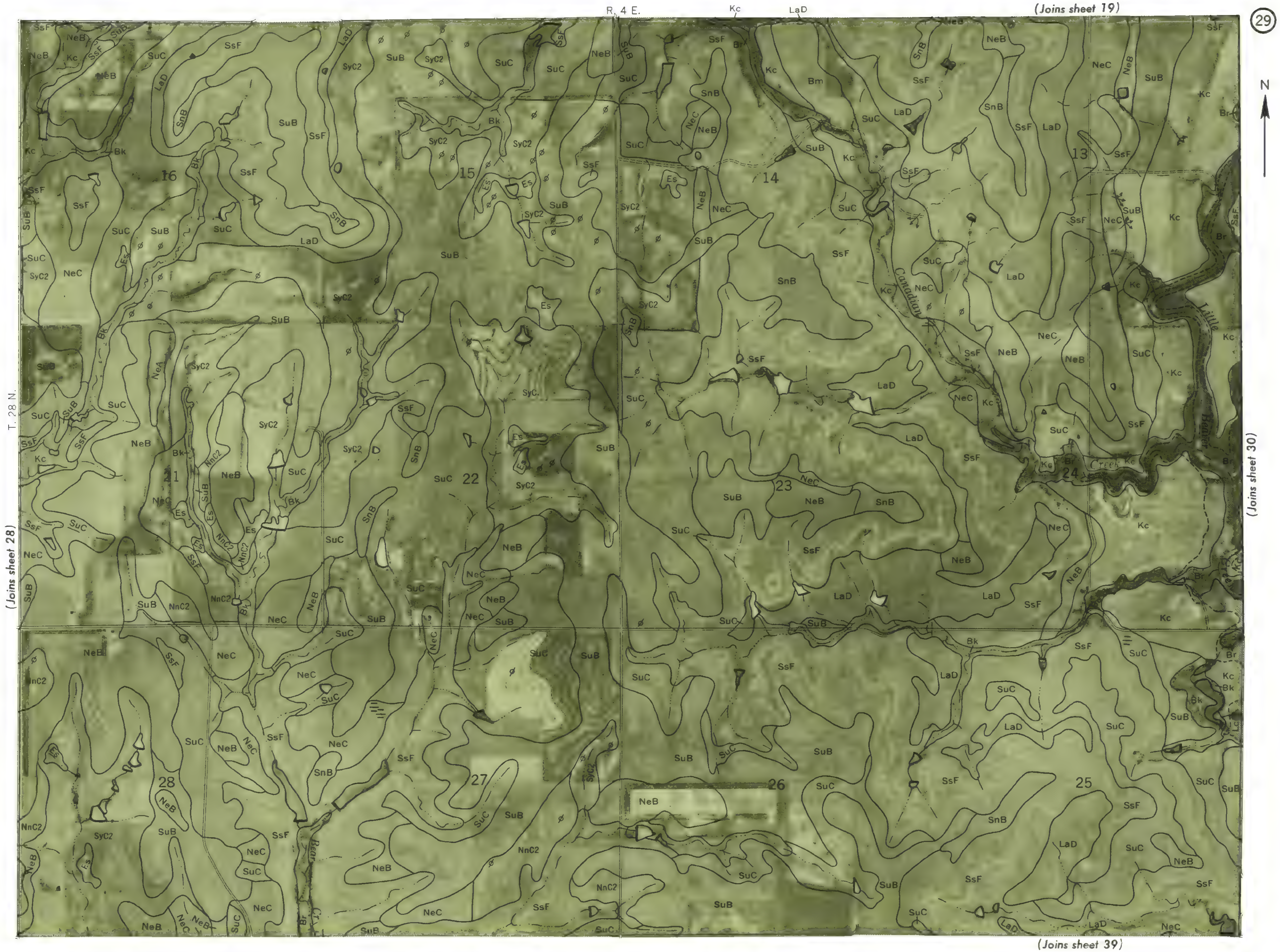
Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 27

0 ½ 1 Mile Scale 1:20000 0 5000 Feet


28
(Joins sheet 18)
(Joins sheet 27)
(Joins sheet 29)
(Joins sheet 38)
R. 3 E. | R. 4 E.
T. 28 N.
N
ARKANSAS RIVER
Sandy Creek
Dry Creek
Wolf Cr
Sweetwater Creek
13
14
17
18
19
20
23
24
25
26
29
30
0 ½ 1 Mile
Scale 1:20000
0 5000 Feet

KAY COUNTY, OKLAHOMA — SHEET NUMBER 29

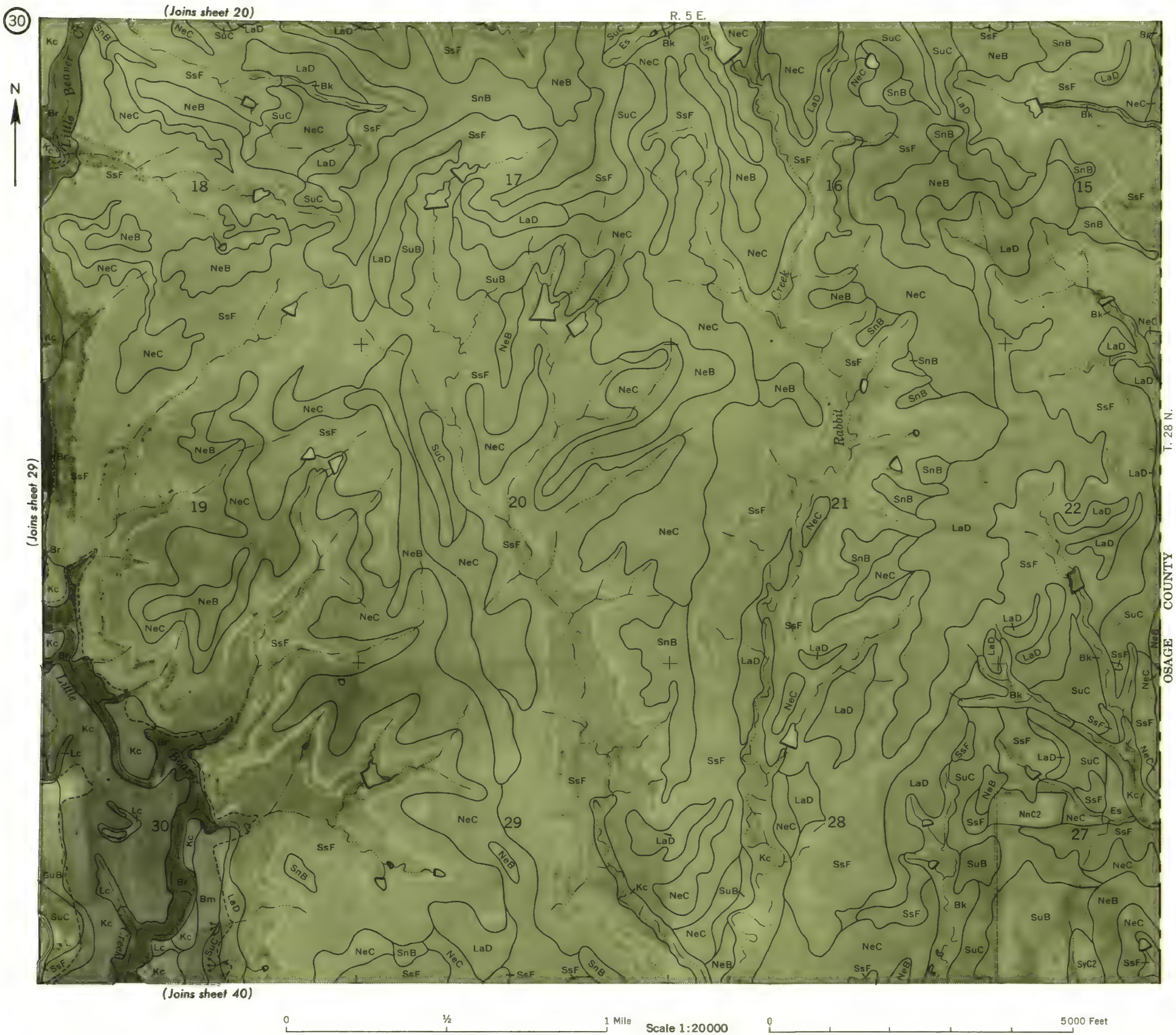


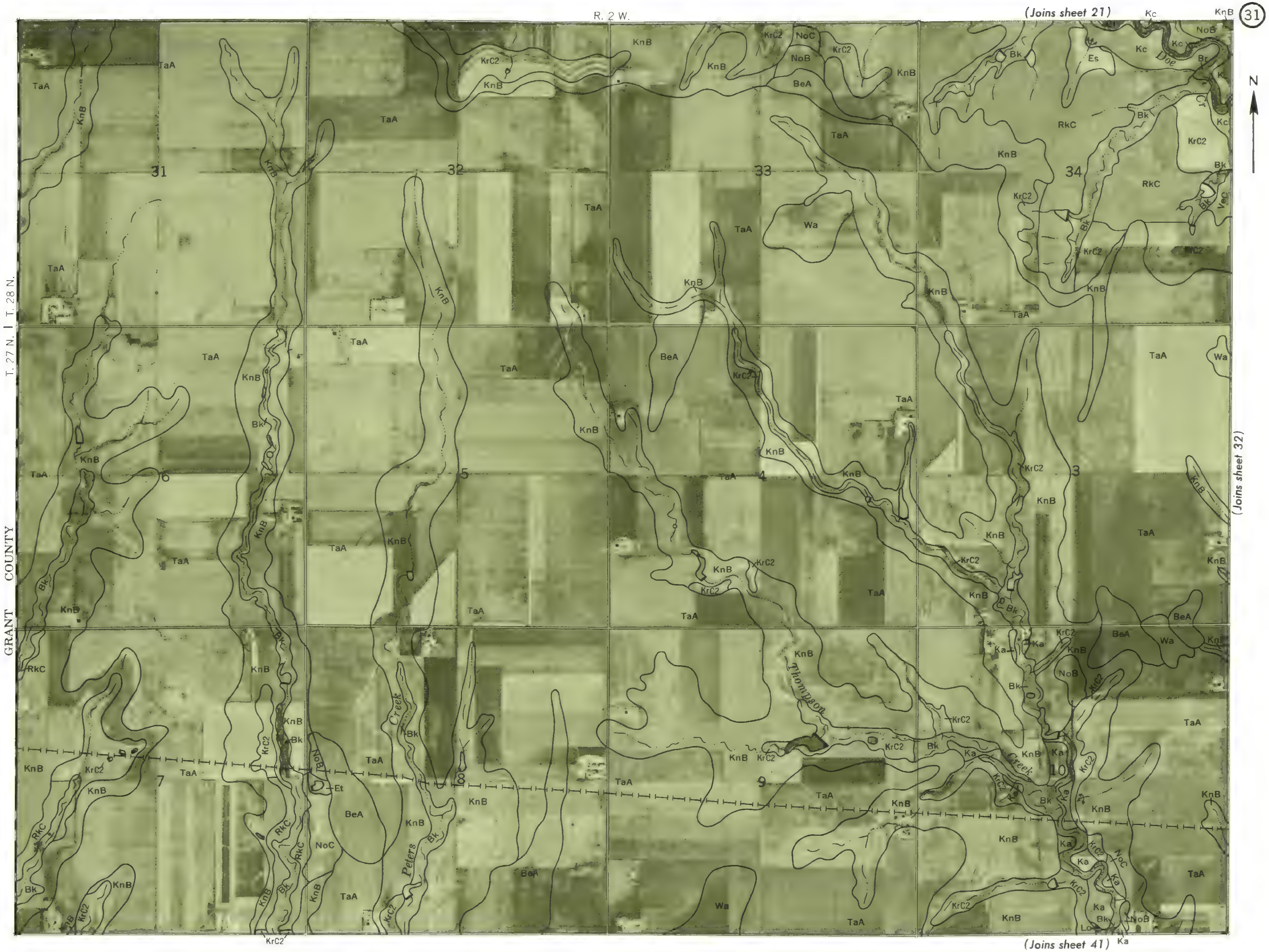
0 ½ 1 Mile Scale 1:20000 0 5000 Feet

KAY COUNTY, OKLAHOMA NO. 29

Land division corners and numbers shown on this map are indefinite.

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.


30
(Joins sheet 20)
R. 5 E.
N
(Joins sheet 29)
T. 28 N.
OSAGE COUNTY
Little Beaver Cr.
Rabbit Creek
Beaver Creek
18
17
16
15
19
20
21
22
30
29
28
27
(Joins sheet 40)
0
½
1 Mile
Scale 1:20000
0
5000 Feet



0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 31

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

KAY COUNTY, OKLAHOMA — SHEET NUMBER 33

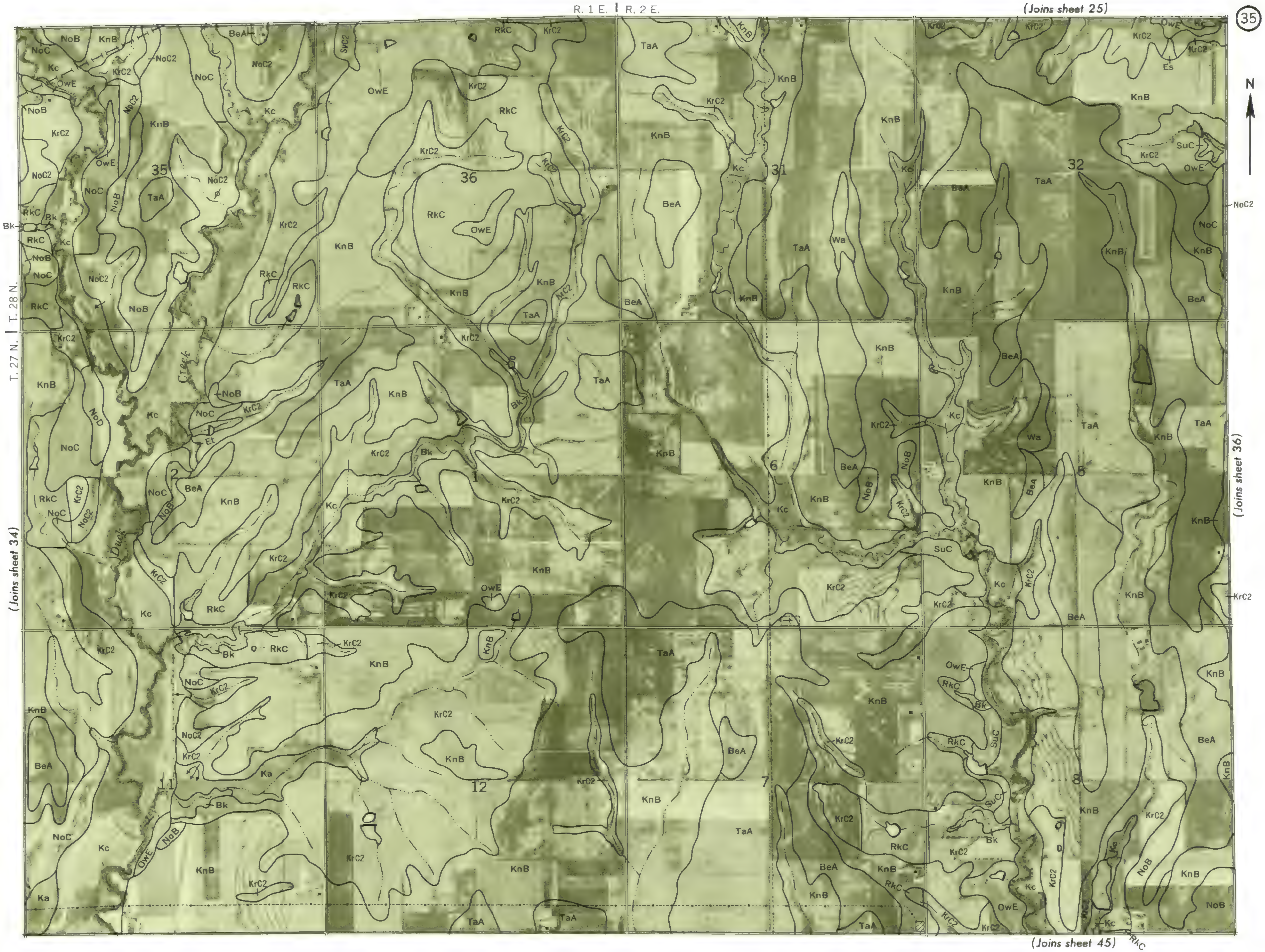
This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite

KAY COUNTY, OKLAHOMA NO. 33

0 ½ 1 Mile Scale 1:20000 0 5000 Feet


34
(Joins sheet 24)
R. 1 E.
N
(Joins sheet 33)
(Joins sheet 35)
(Joins sheet 44)
T. 28 N.
T. 27 N.
Grainville
Lost Creek School
31
32
33
34
6
5
4
3
7
8
9
10
0 ½ 1 Mile
Scale 1:20000
0 5000 Feet



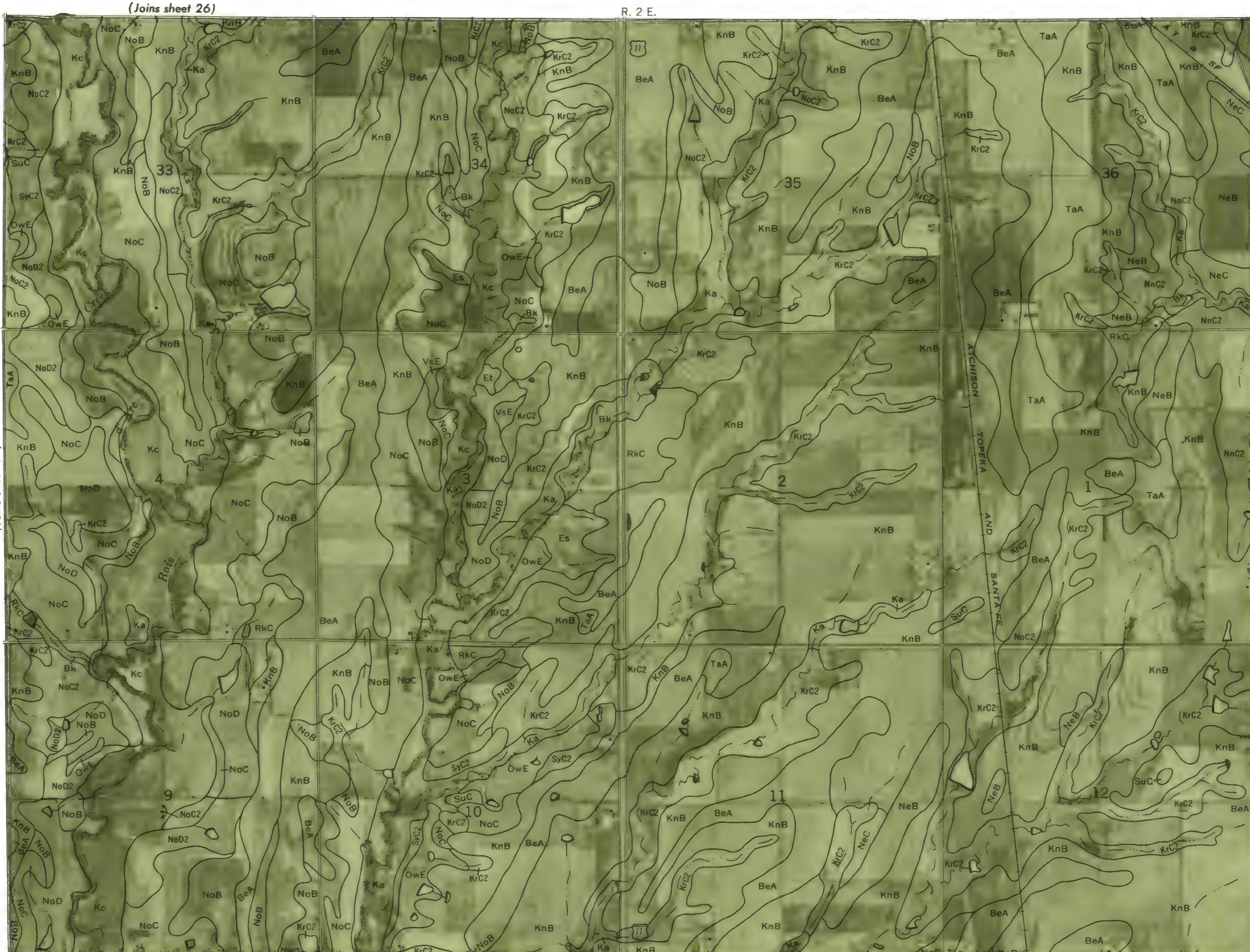
0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 35

36



0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 37

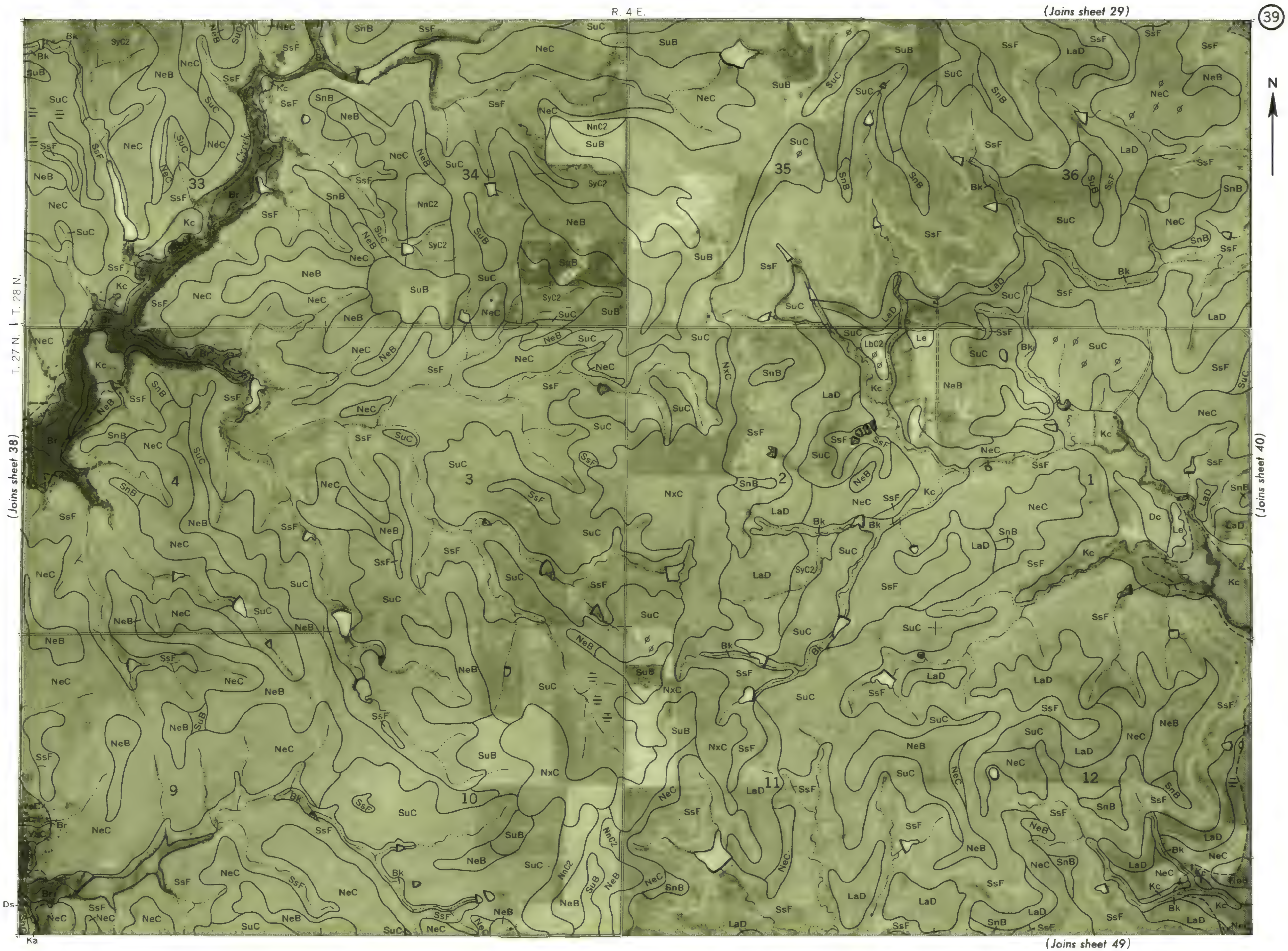
0 ½ 1 Mile Scale 1:20000 0 5000 Feet

38

(Joins sheet 28)

(Joins sheet 48)

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

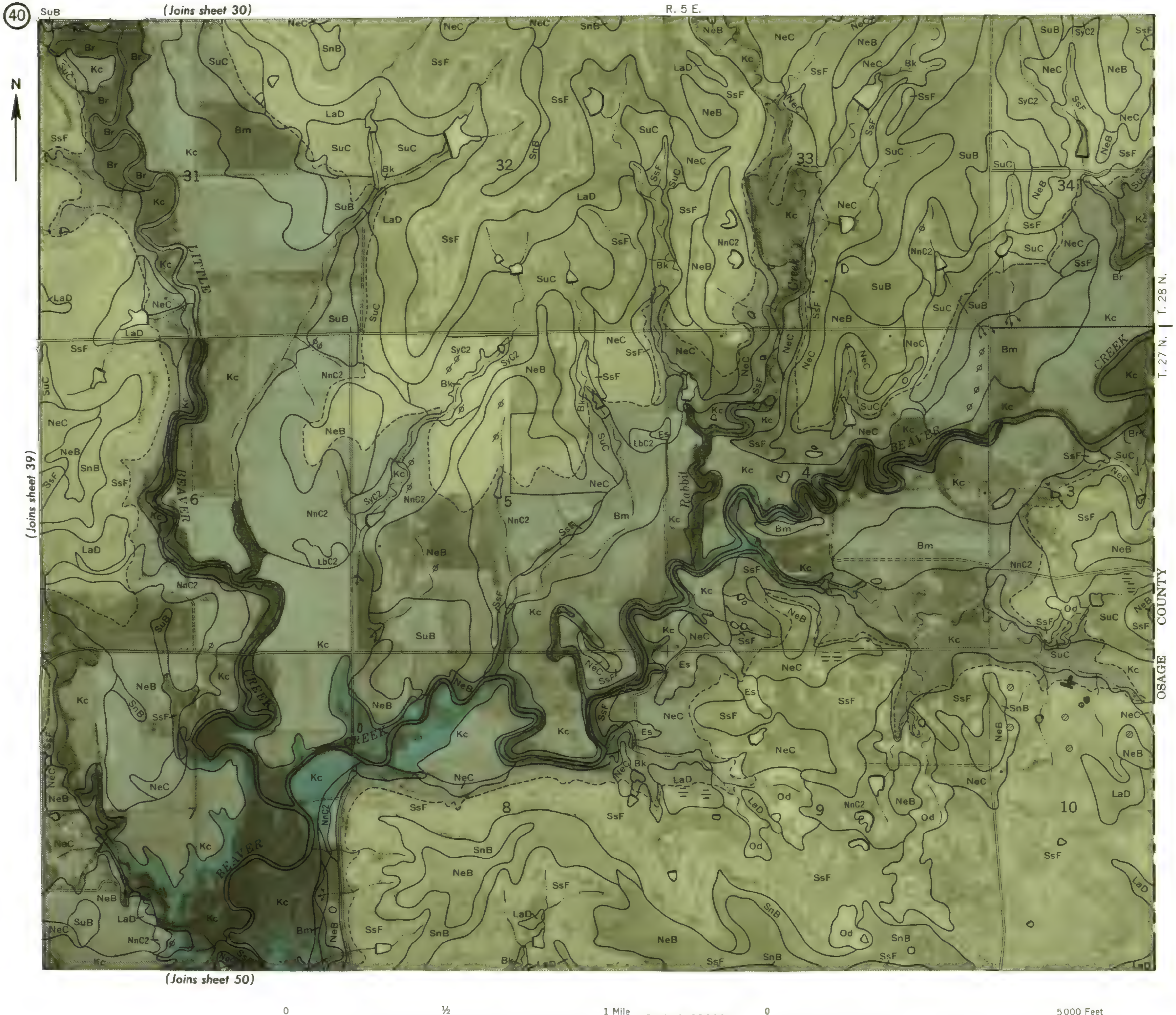


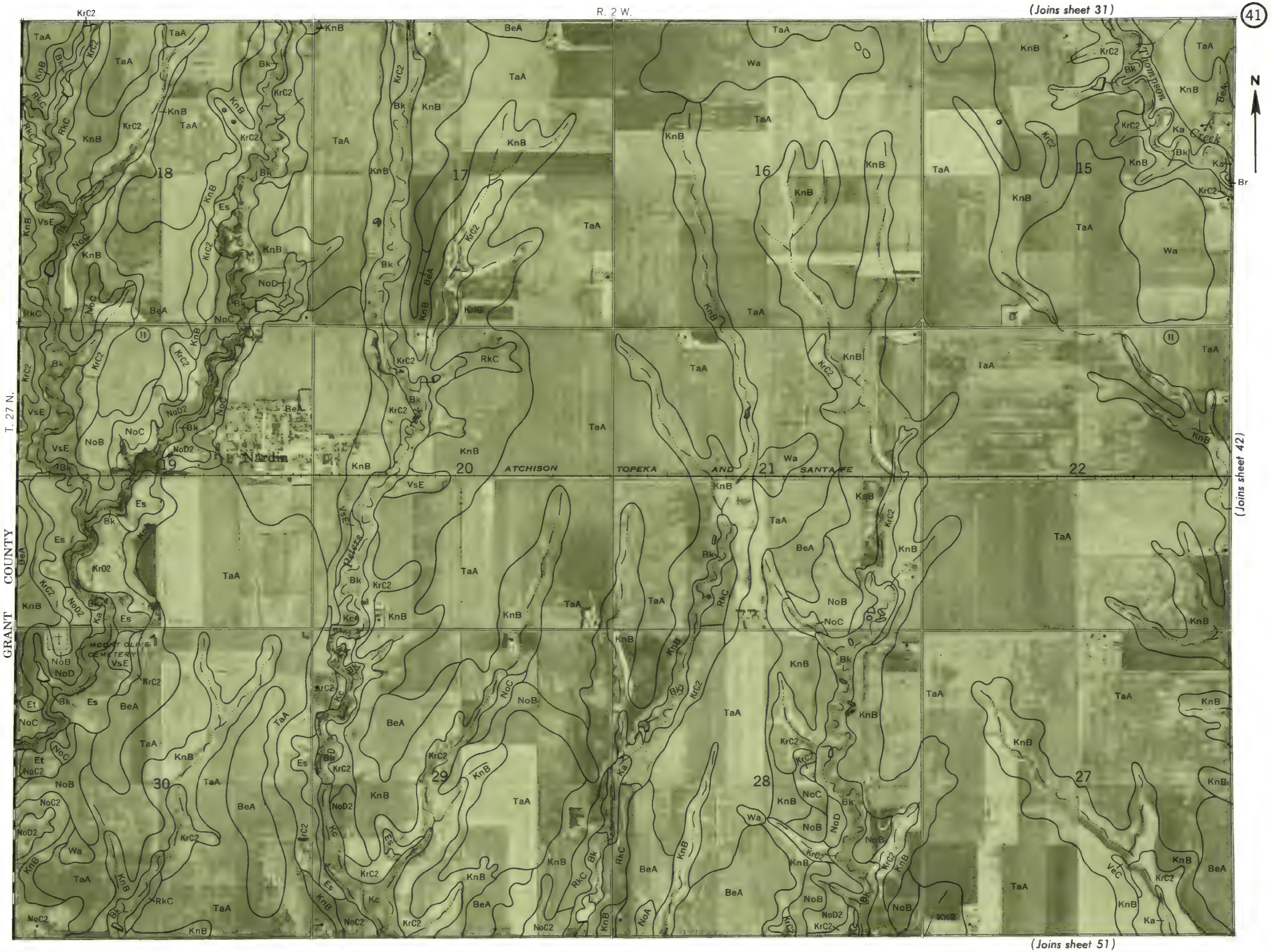
0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 39


40
(Joins sheet 30)
R. 5 E.
(Joins sheet 39)
(Joins sheet 50)
N
T. 28 N.
T. 27 N.
LITTLE
BEAVER
CREEK
Rabbit
Creek
OSAGE
COUNTY
31
32
33
34
6
5
4
3
7
8
9
10
SuB
SuC
SsF
NeC
NeB
Kc
Br
Bm
Bk
LaD
SnB
SyC2
NnC2
LbC2
Es
Od
0
½
1 Mile
Scale 1:20000
0
5000 Feet



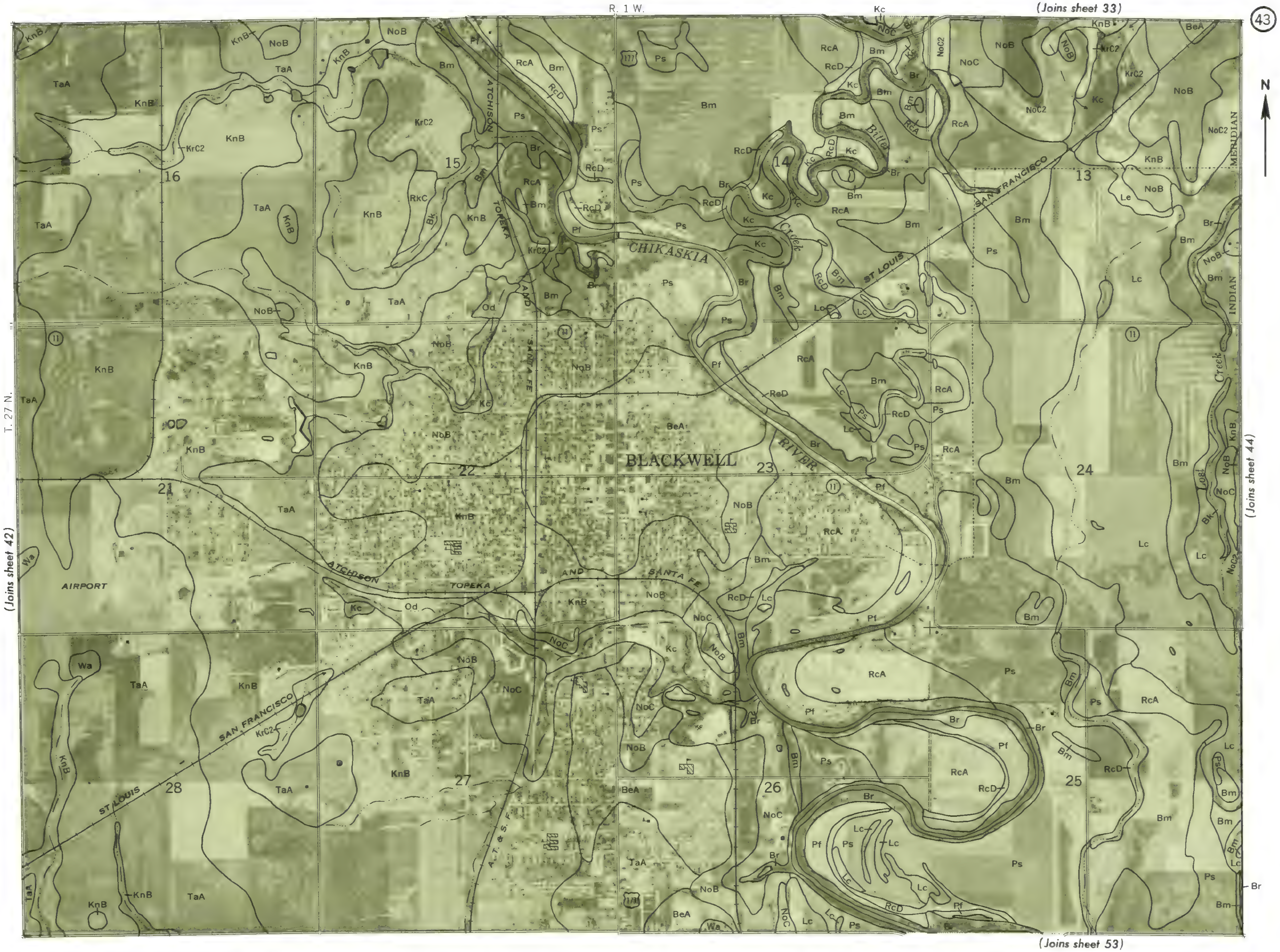
0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.


42
(Joins sheet 32)
R. 2 W. | R. 1 W.
N
(Joins sheet 41)
(Joins sheet 43)
T. 27 N.
(Joins sheet 52)
ATCHISON TOPEKA AND SANTA FE
COUNTRY CLUB
Cooper School
Thompson Creek
Stink Creek
13
14
17
18
19
20
23
24
25
26
29
30
0 ½ 1 Mile
Scale 1:20000
0 5000 Feet

KAY COUNTY, OKLAHOMA — SHEET NUMBER 43

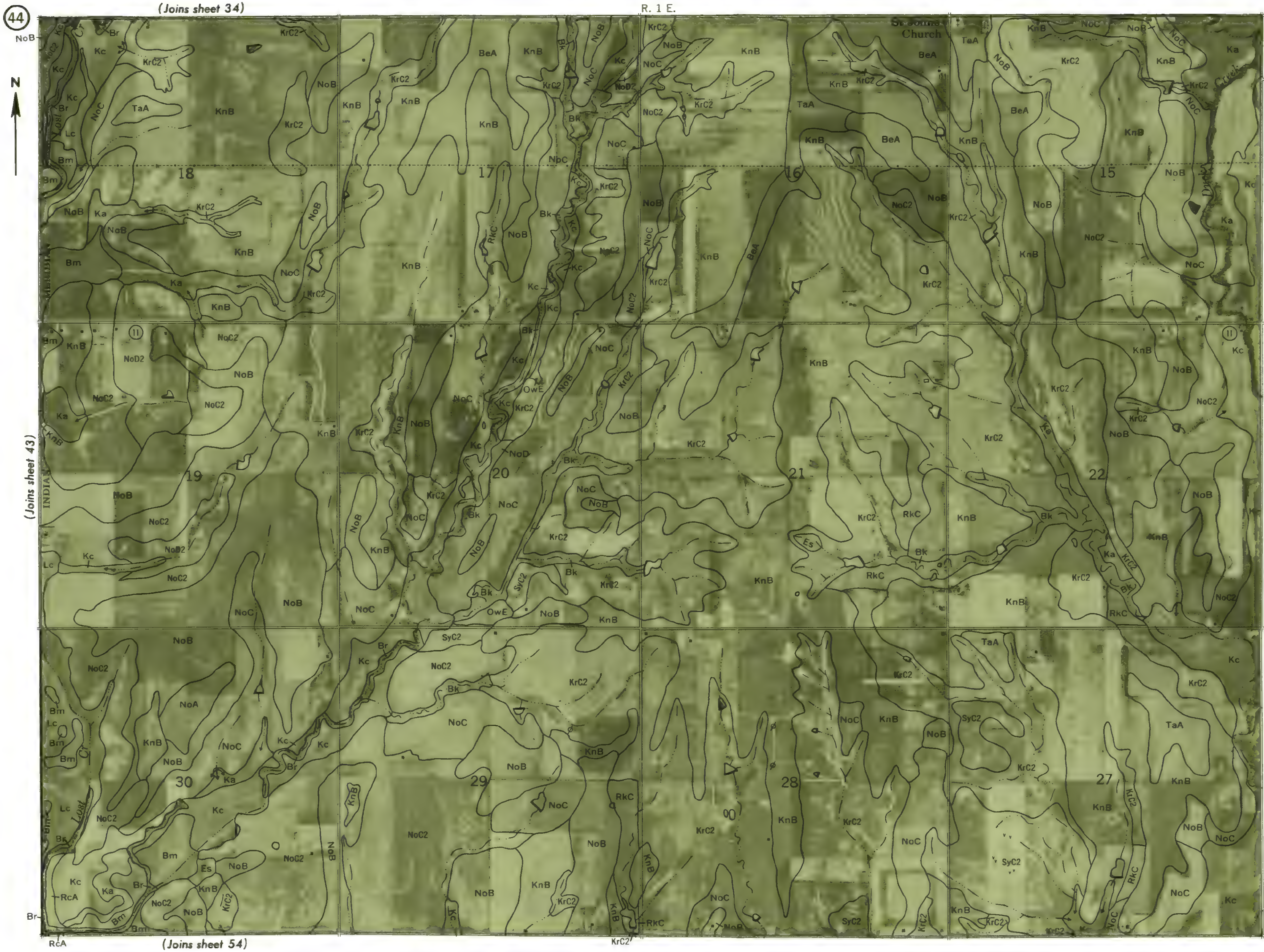


0 ½ 1 Mile Scale 1:20000 0 5000 Feet

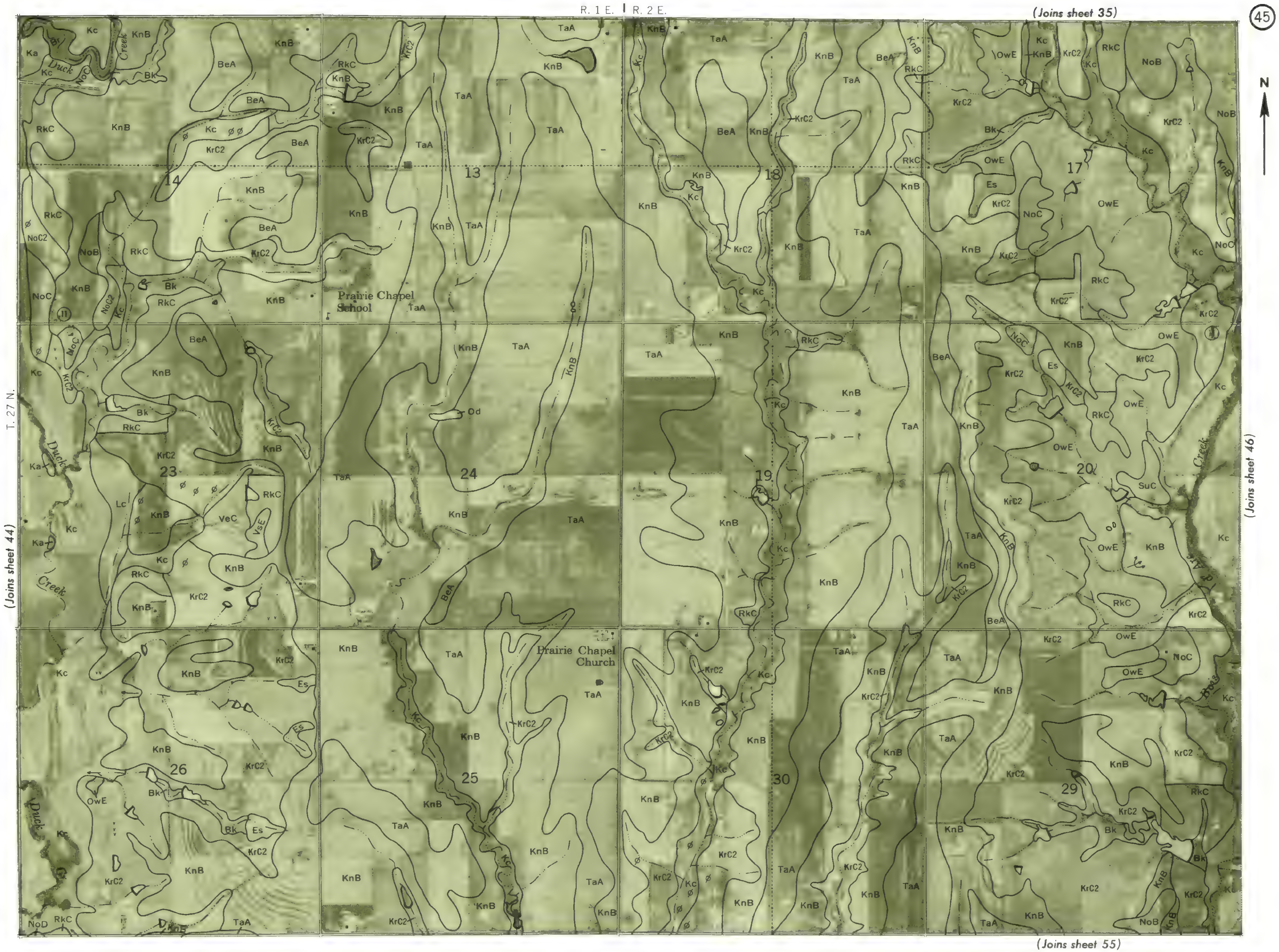
This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO 43



0 ½ 1 Mile Scale 1:20000 0 5000 Feet



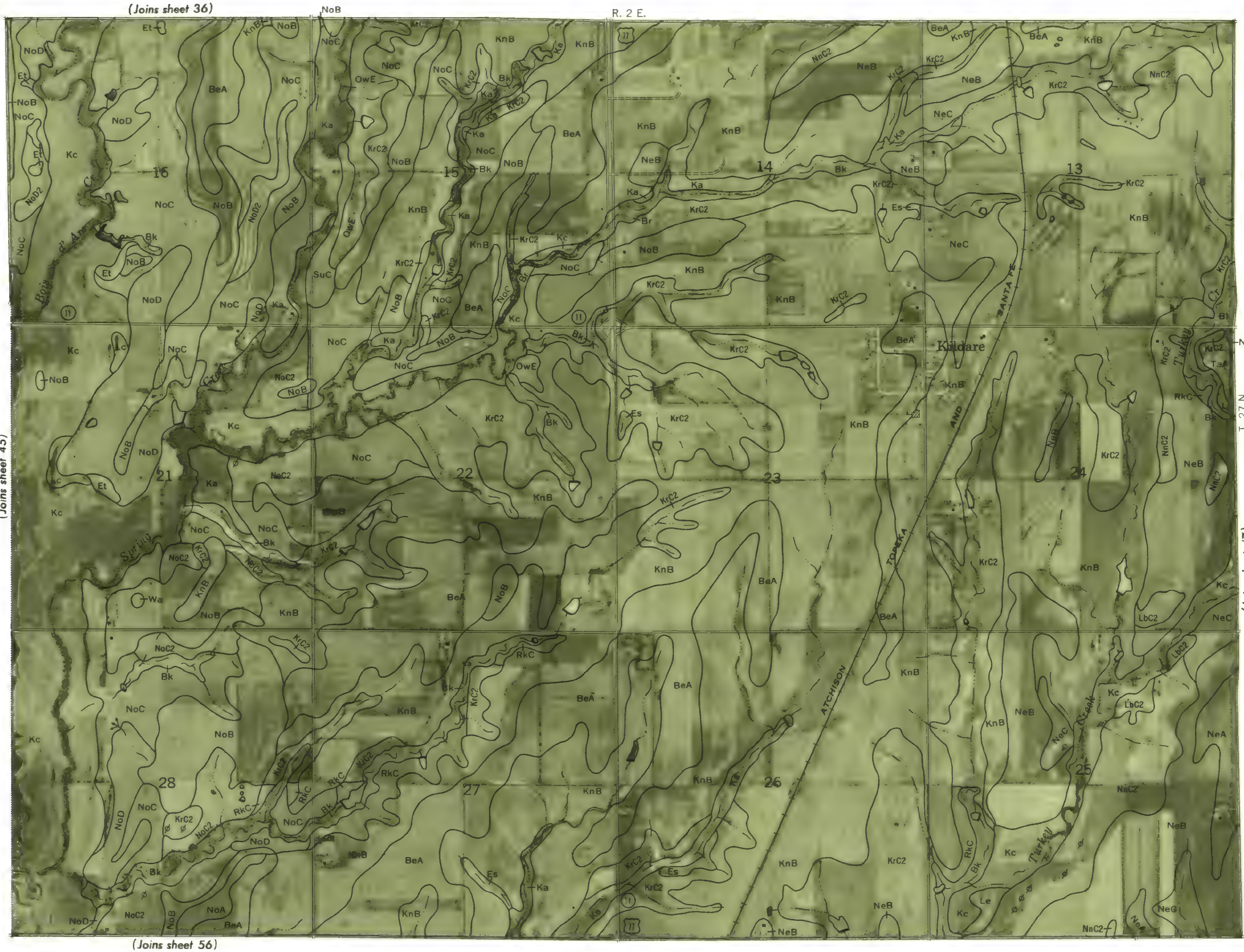
0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

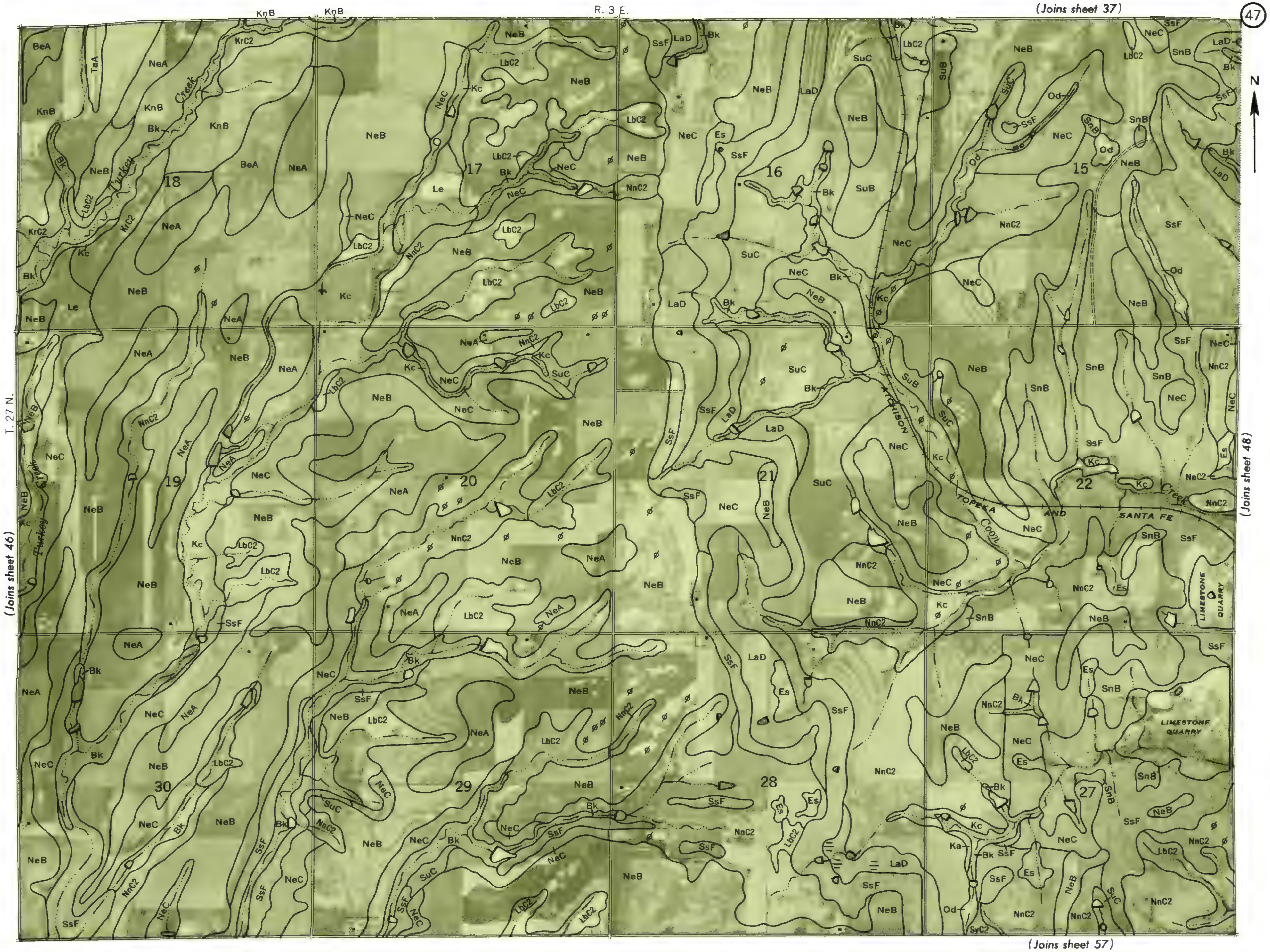
KAY COUNTY, OKLAHOMA NO. 45

KAY COUNTY, OKLAHOMA — SHEET NUMBER 46



0 ½ 1 Mile Scale 1:20000 0 5000 Feet

KAY COUNTY, OKLAHOMA NO. 46

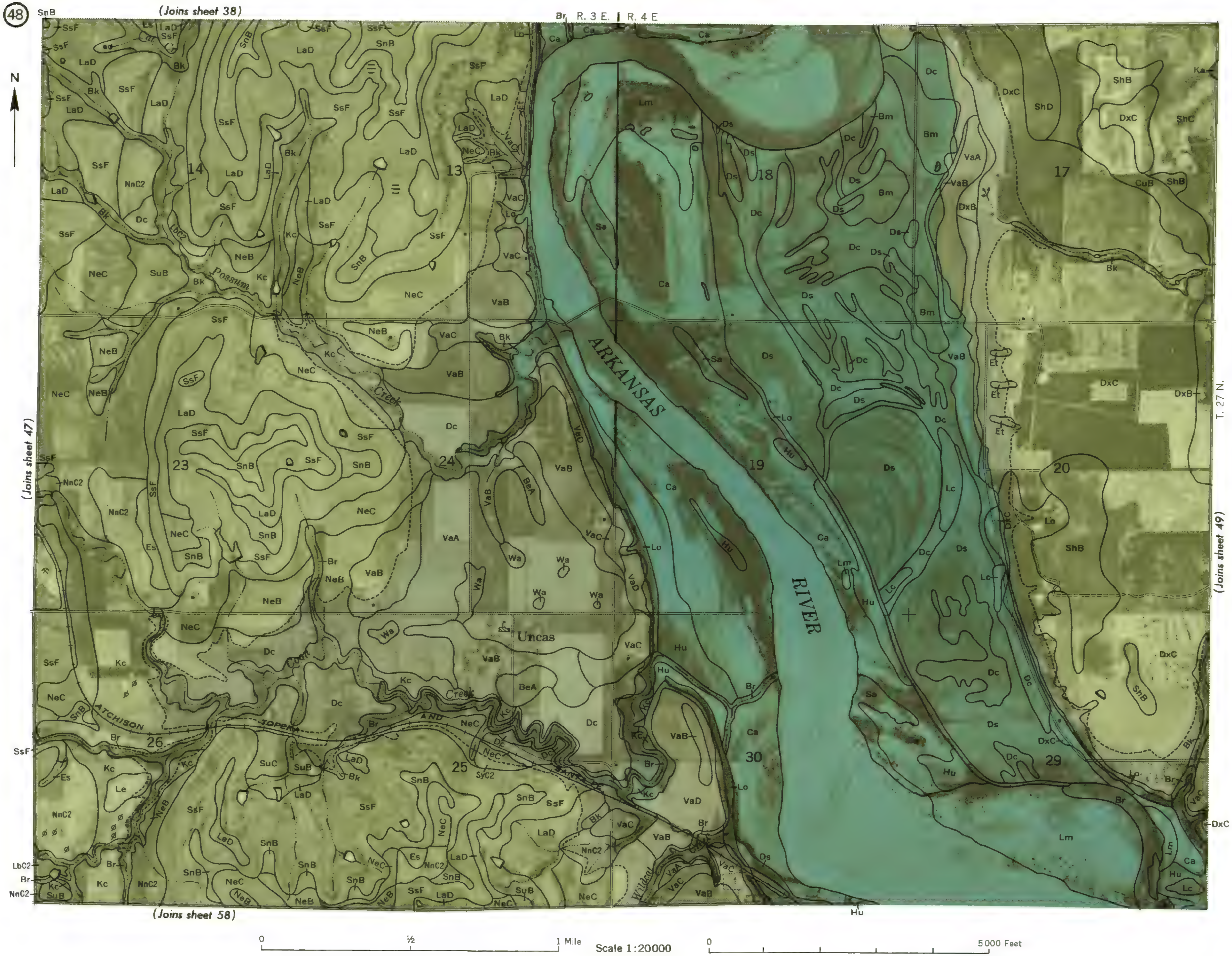


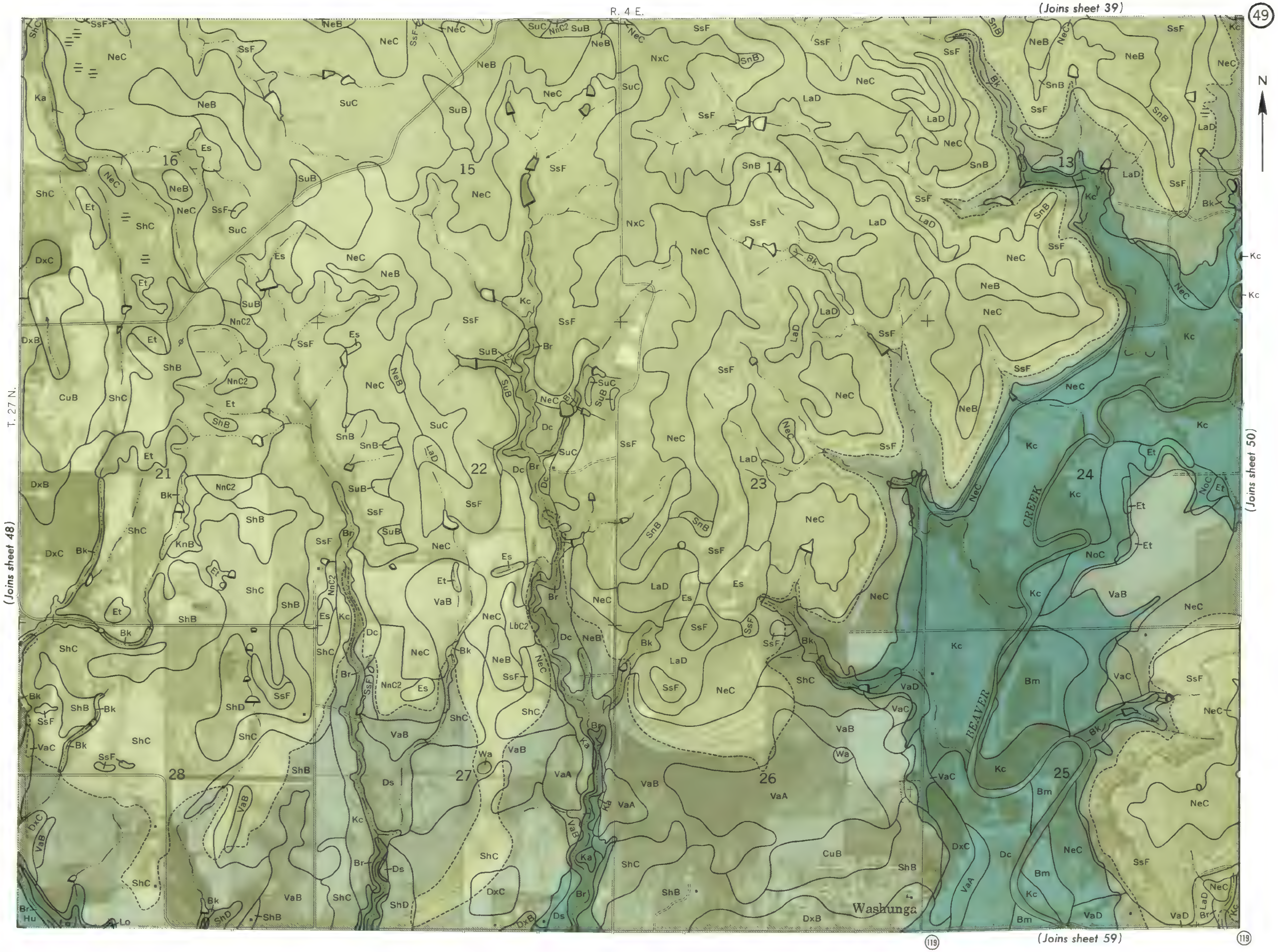
0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO 17

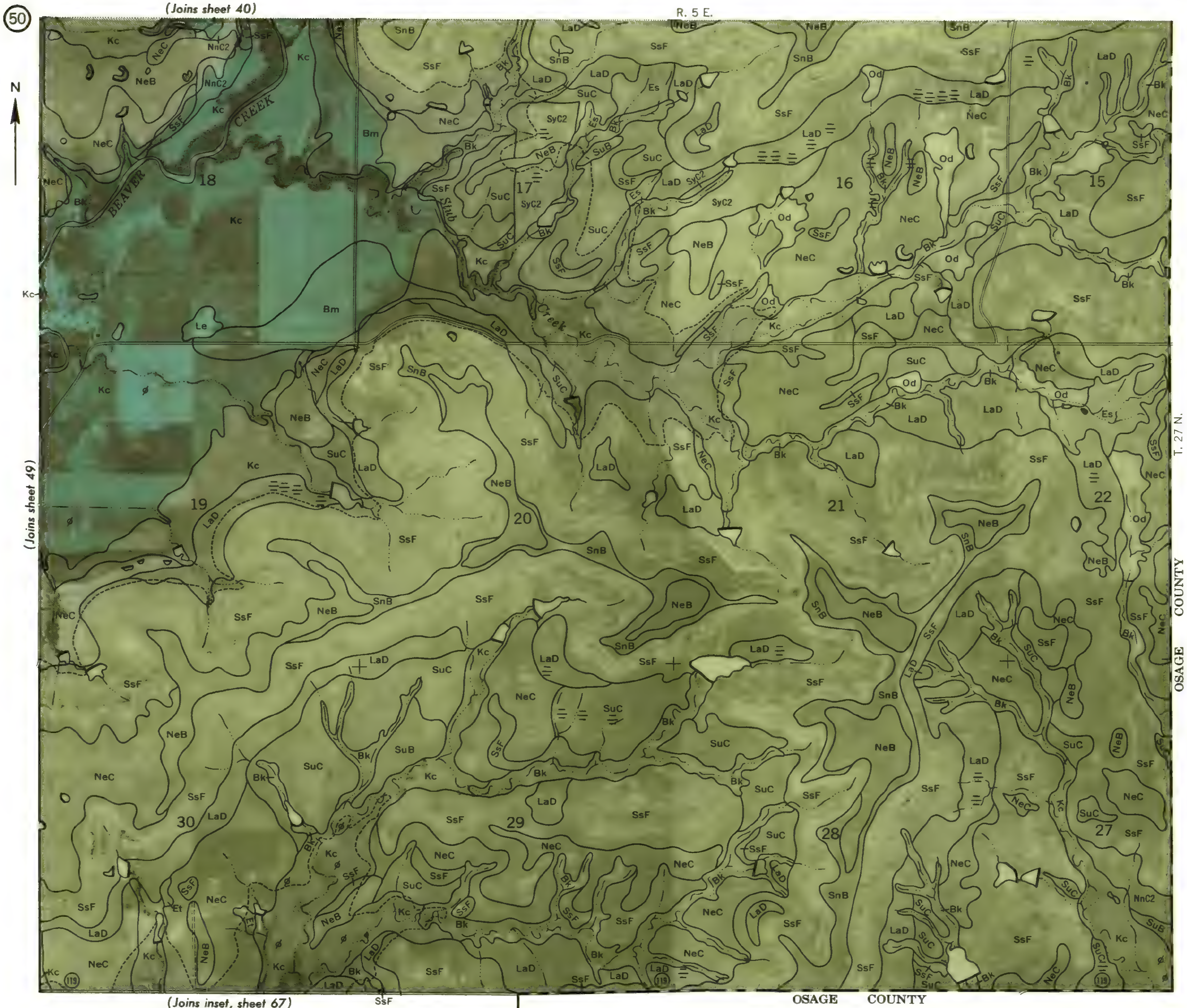

48
(Joins sheet 38)
R. 3 E. R. 4 E.
N
(Joins sheet 47)
(Joins sheet 49)
(Joins sheet 58)
T. 27 N.
ARKANSAS
RIVER
Uncas
Possum Creek
Coon Creek
ATCHISON TOPEKA AND SANTA FE
Wildcat
13
14
17
18
19
20
23
24
25
26
29
30
0 ½ 1 Mile
Scale 1:20000
0 5000 Feet



0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1956 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.



0 ½ 1 Mile Scale 1:20000 0 5000 Feet

KAY COUNTY, OKLAHOMA — SHEET NUMBER 51

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO -

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

KAY COUNTY, OKLAHOMA — SHEET NUMBER 52

52

(Joins sheet 42)

R. 2 W. | R. 1 W.

N

(Joins sheet 51)

T. 27 N. | T. 26 N.

(Joins sheet 53)

(Joins sheet 61)

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

KAY COUNTY, OKLAHOMA NO. 52

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 53


54
(Joins sheet 44)
R. 1 E.
N
(Joins sheet 53)
(Joins sheet 55)
(Joins sheet 63)
T. 27 N.
T. 26 N.
INDIAN MERIDIAN
CHIKASKIA RIVER
East Creek
Duck Creek
Creek
31
32
33
34
6
5
4
3
7
8
9
10
0 ½ 1 Mile
Scale 1:20000
0 5000 Feet

KAY COUNTY, OKLAHOMA — SHEET NUMBER 55

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

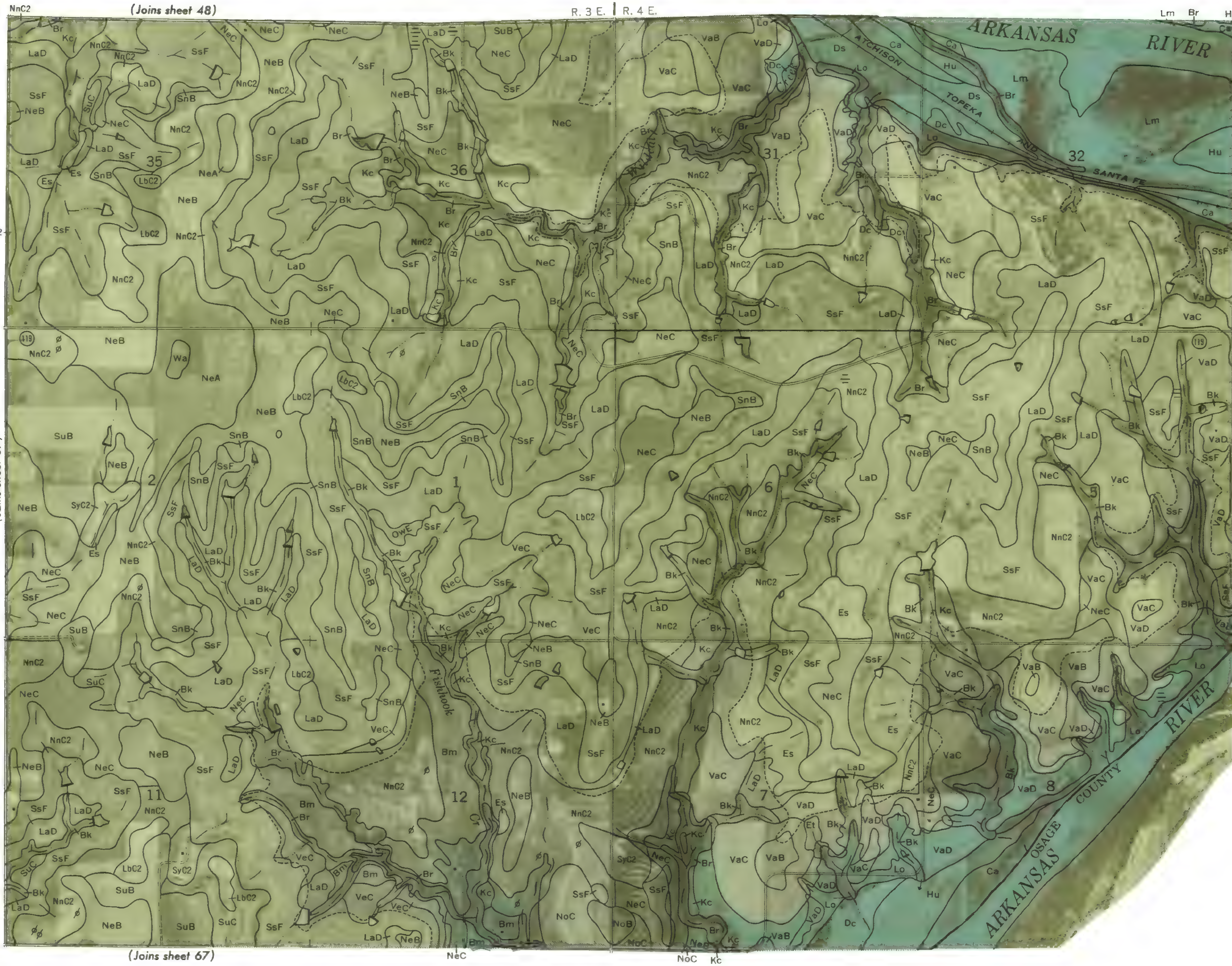
KAY COUNTY, OKLAHOMA — SHEET NUMBER 57

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

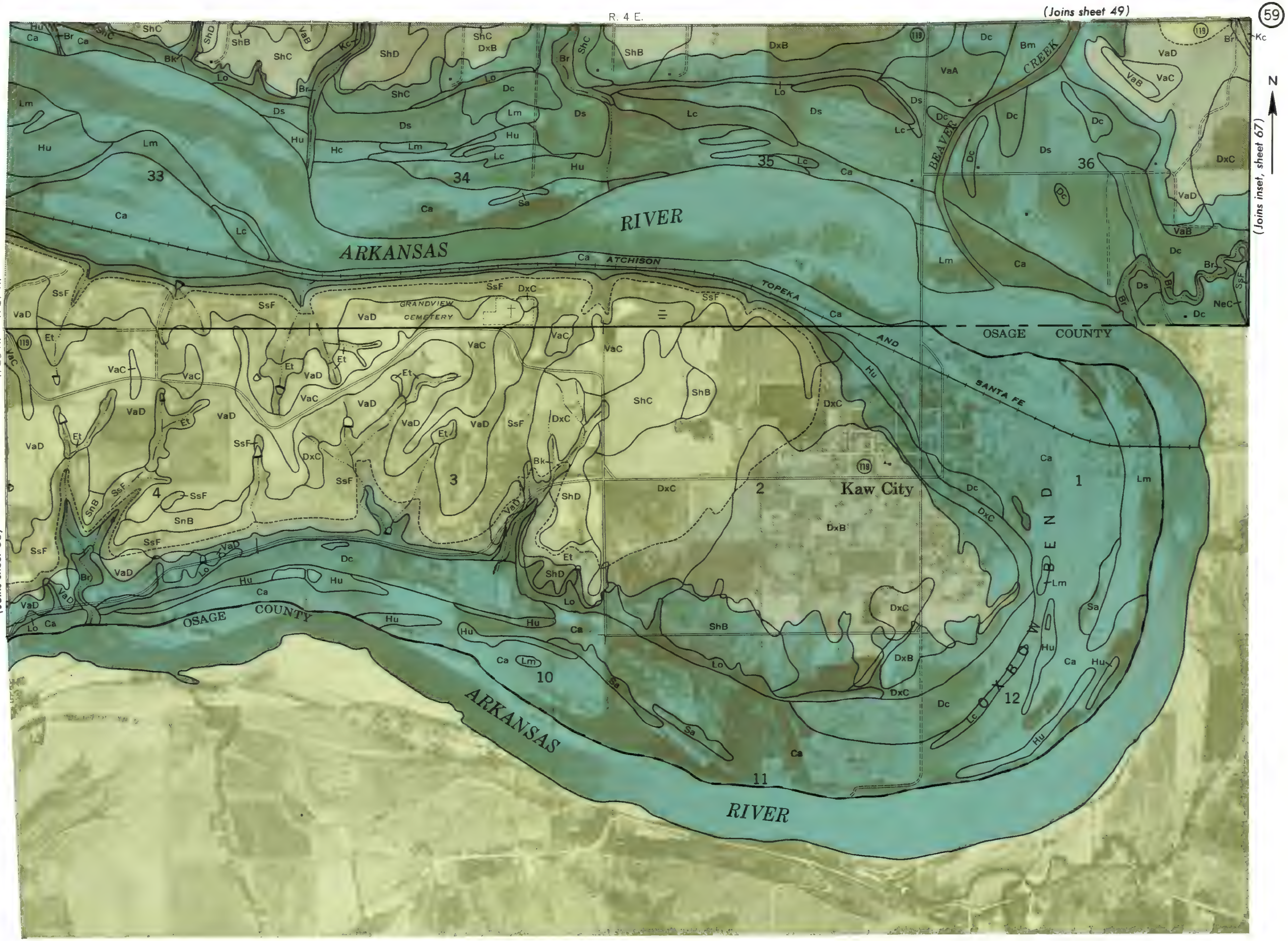
This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 57



0 ½ 1 Mile Scale 1:20000 0 5000 Feet



0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

60

(Joins sheet 51)

R. 2 W.

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

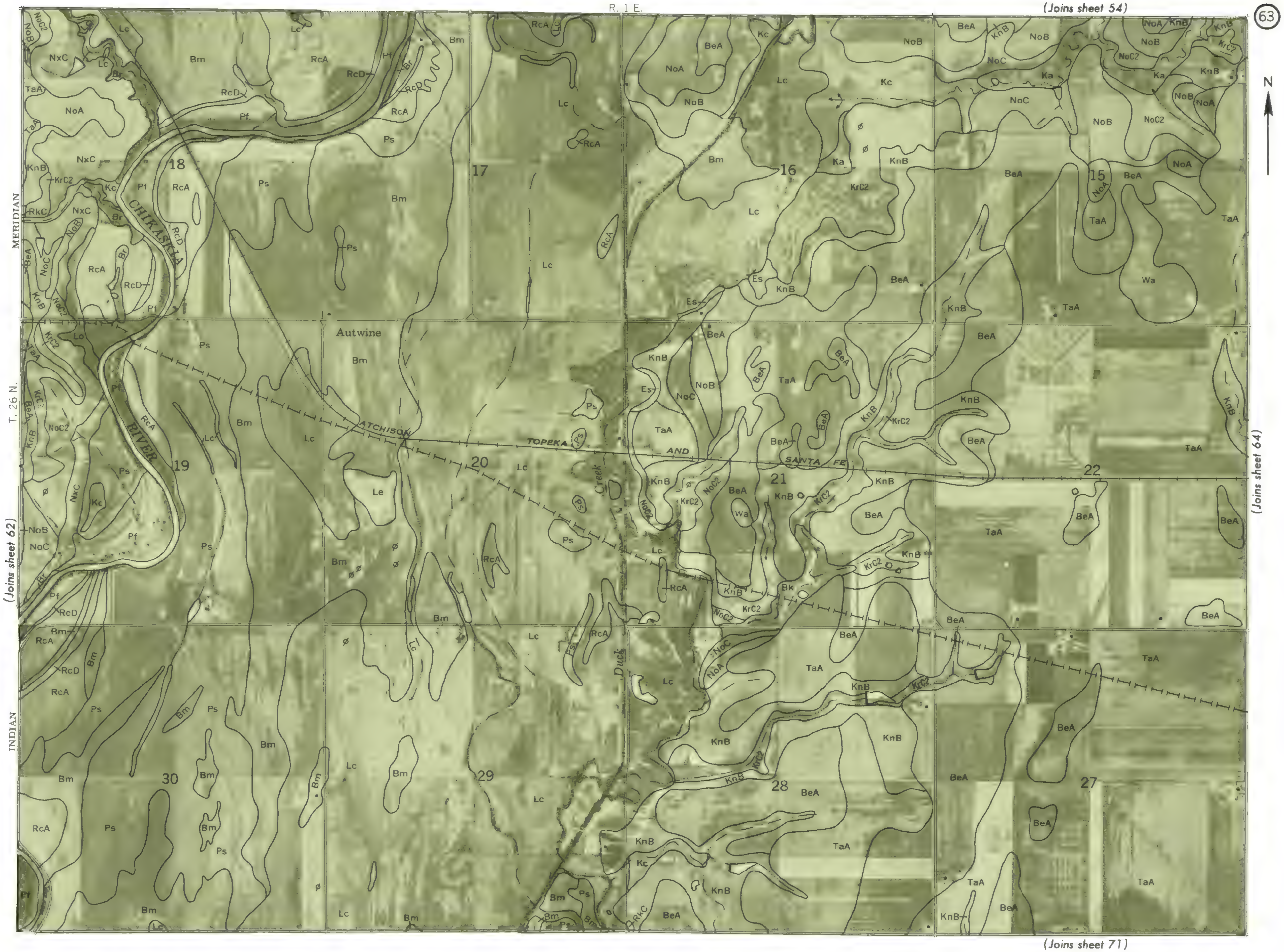
0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 61


62
(Joins sheet 53)
R. 1 W.
T. 26 N.
(Joins sheet 61)
(Joins sheet 63)
(Joins sheet 70)
Stink Creek
CHIKASKIA RIVER
Tyner
ATCHISON TOPEKA AND SANTA FE
INDIAN MERIDIAN
N
0 ½ 1 Mile
Scale 1:20000
0 5000 Feet



0 ½ 1 Mile Scale 1:20000 0 5000 Feet

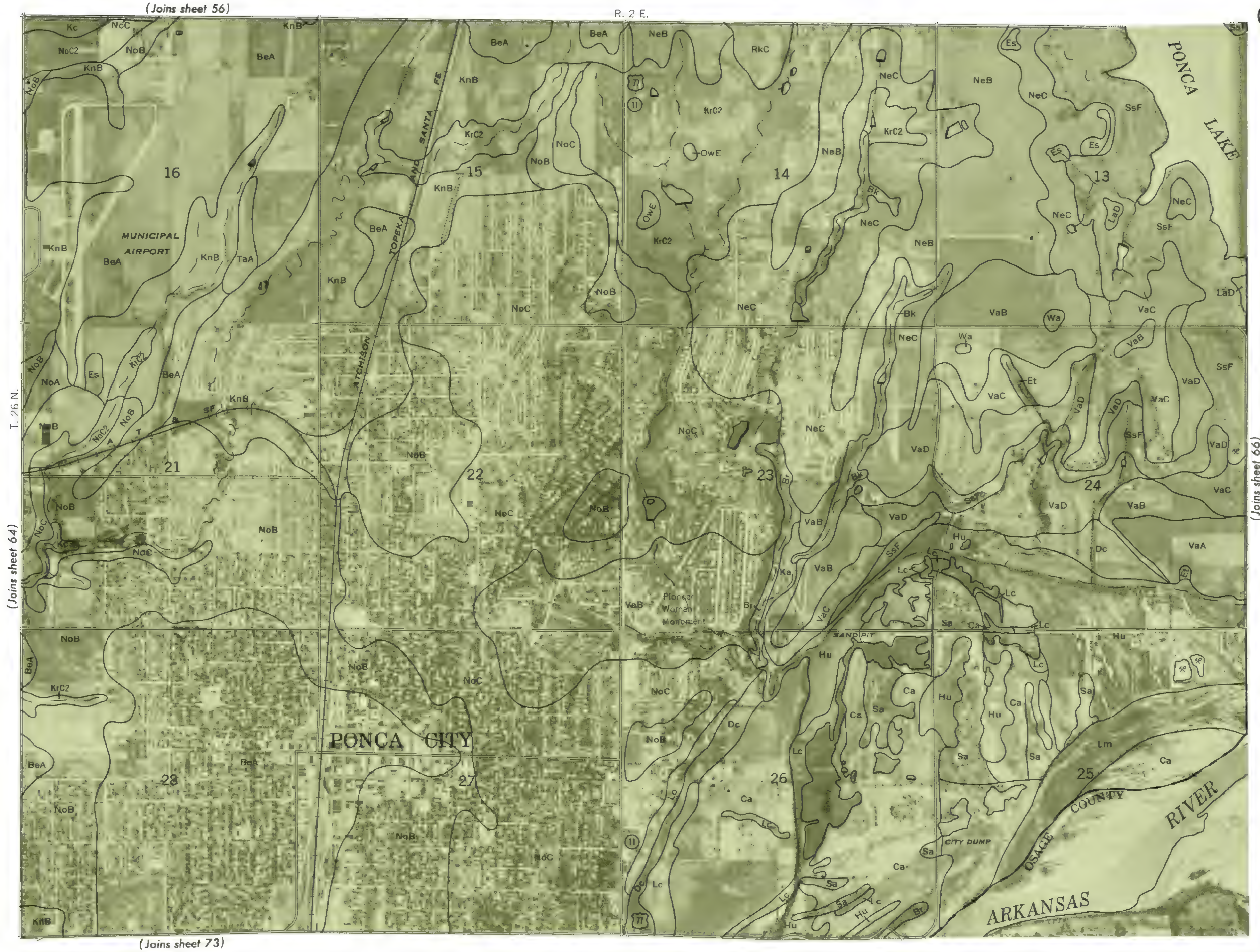
This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 63


64
(Joins sheet 55)
R. 1 E. R. 2 E.
N
(Joins sheet 63)
(Joins sheet 65)
(Joins sheet 72)
T. 26 N.
ATCHISON
TOPEKA
AND
SANTA
FE
Bois d' Arc Creek
Finley School
PUMPING STATION
0
½
1 Mile
Scale 1:20000
0
5000 Feet

65

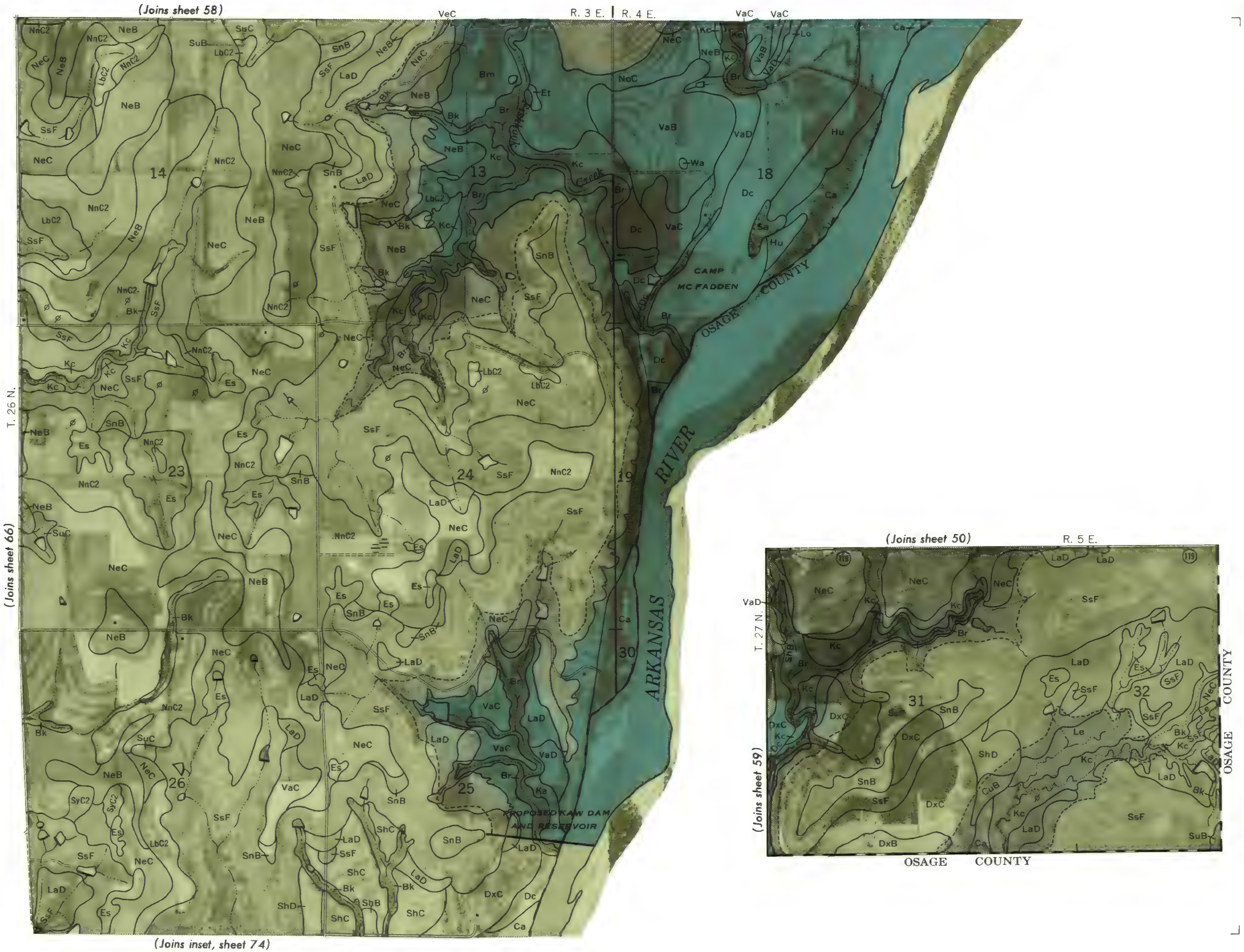


0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

0 ½ 1 Mile Scale 1:20000 0 5000 Feet



0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 67

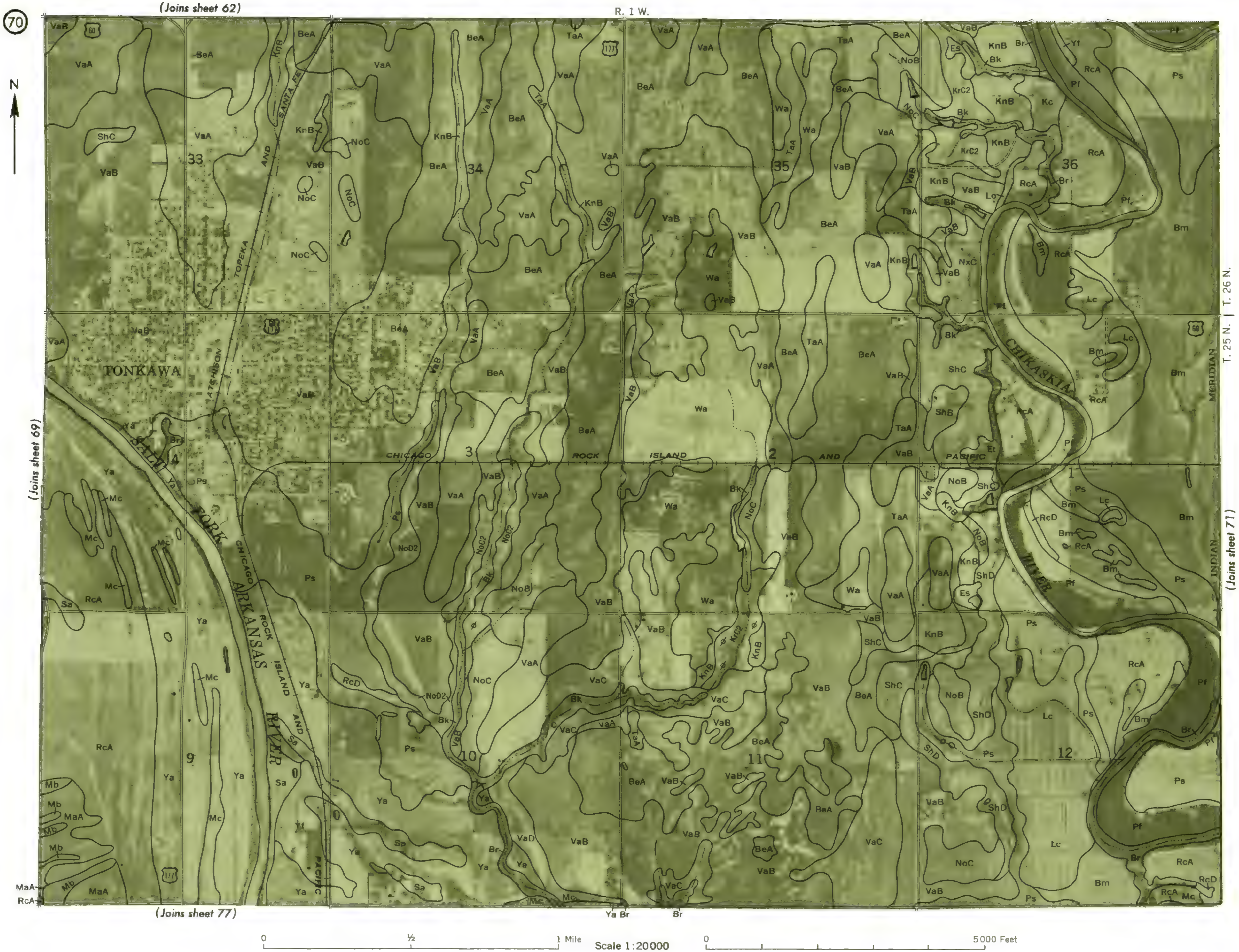

68
(Joins sheet 60)
R. 2 W.
N
T. 26 N.
T. 25 N.
GRANT COUNTY
(Joins sheet 69)
(Joins sheet 75)
SALT FORK ARKANSAS RIVER
31
32
33
34
6
5
4
3
7
8
9
10
0
½
1 Mile
Scale 1:20000
0
5000 Feet

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

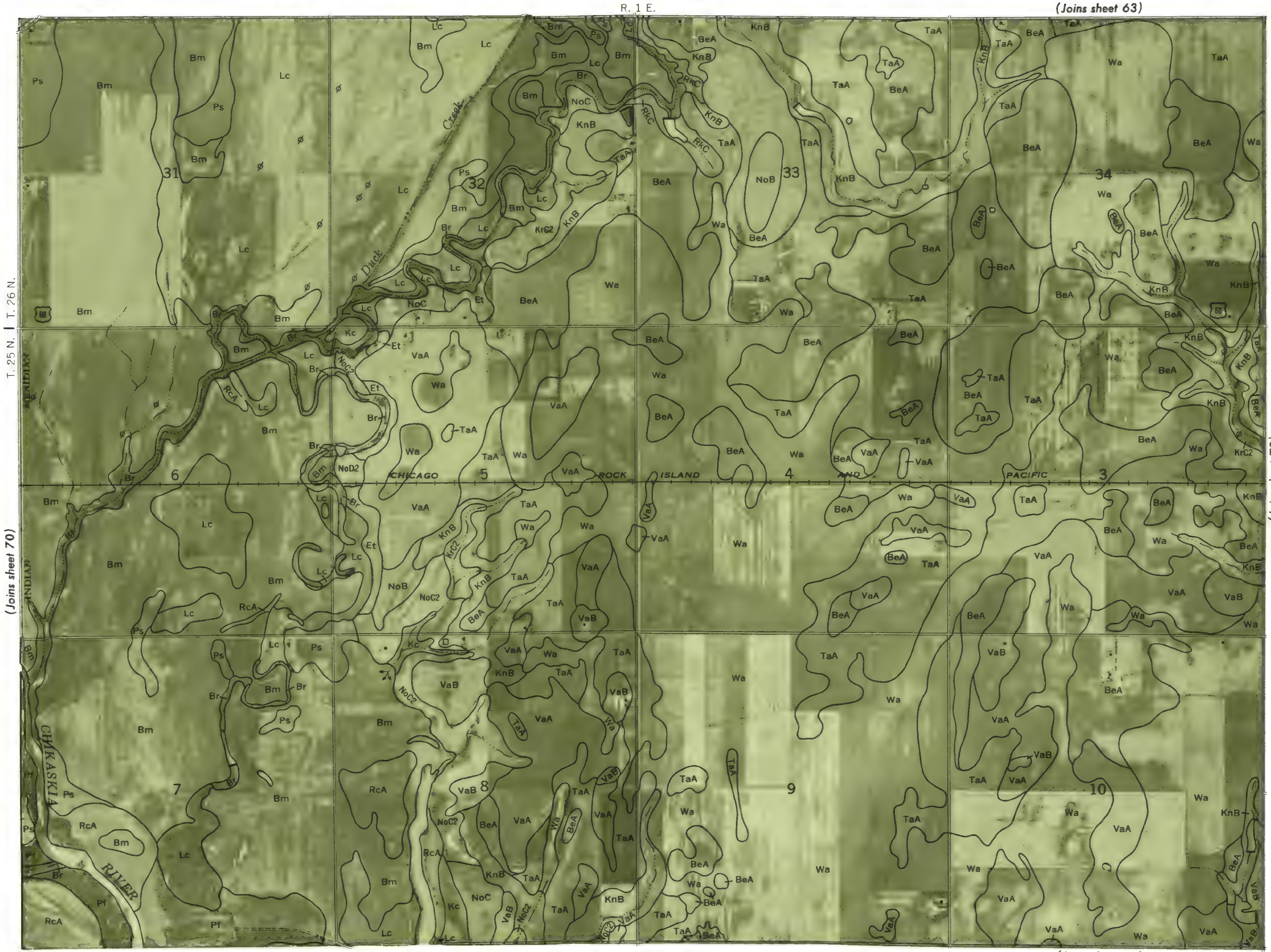
KAY COUNTY, OKLAHOMA NO. 69


70
(Joins sheet 62)
R. 1 W.
N
TONKAWA
CHIKASKIA RIVER
SALT FORK ARKANSAS RIVER
ATCHISON TOPEKA AND SANTA FE
CHICAGO ROCK ISLAND AND PACIFIC
T. 26 N.
T. 25 N.
INDIAN MERIDIAN
(Joins sheet 69)
(Joins sheet 71)
(Joins sheet 77)
33
34
35
36
4
3
2
1
9
10
11
12
0
½
1 Mile
Scale 1:20000
0
5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 71



0 ½ 1 Mile Scale 1:20000 0 5000 Feet

72

(Joins sheet 64)

R. 1 E. | R. 2 E.

N

(Joins sheet 71)

(Joins sheet 73)

T. 26 N. | T. 25 N.

(Joins sheet 79)

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

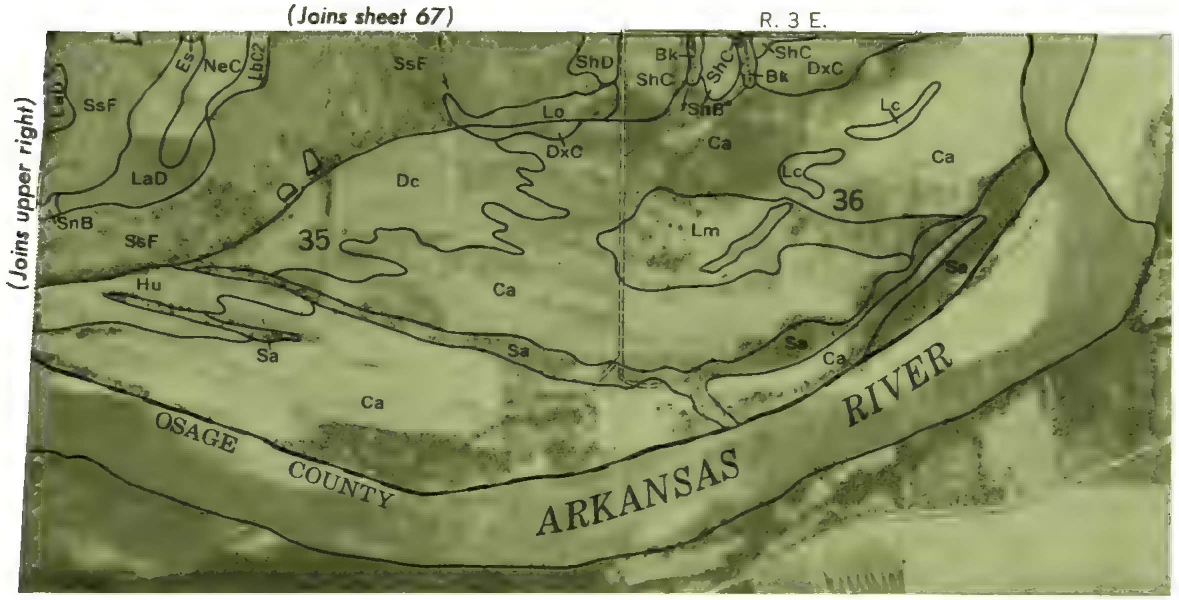
This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 73

74

N



0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 75

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

KAY COUNTY, OKLAHOMA — SHEET NUMBER 76

76

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

KAY COUNTY, OKLAHOMA NO. 76

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 77

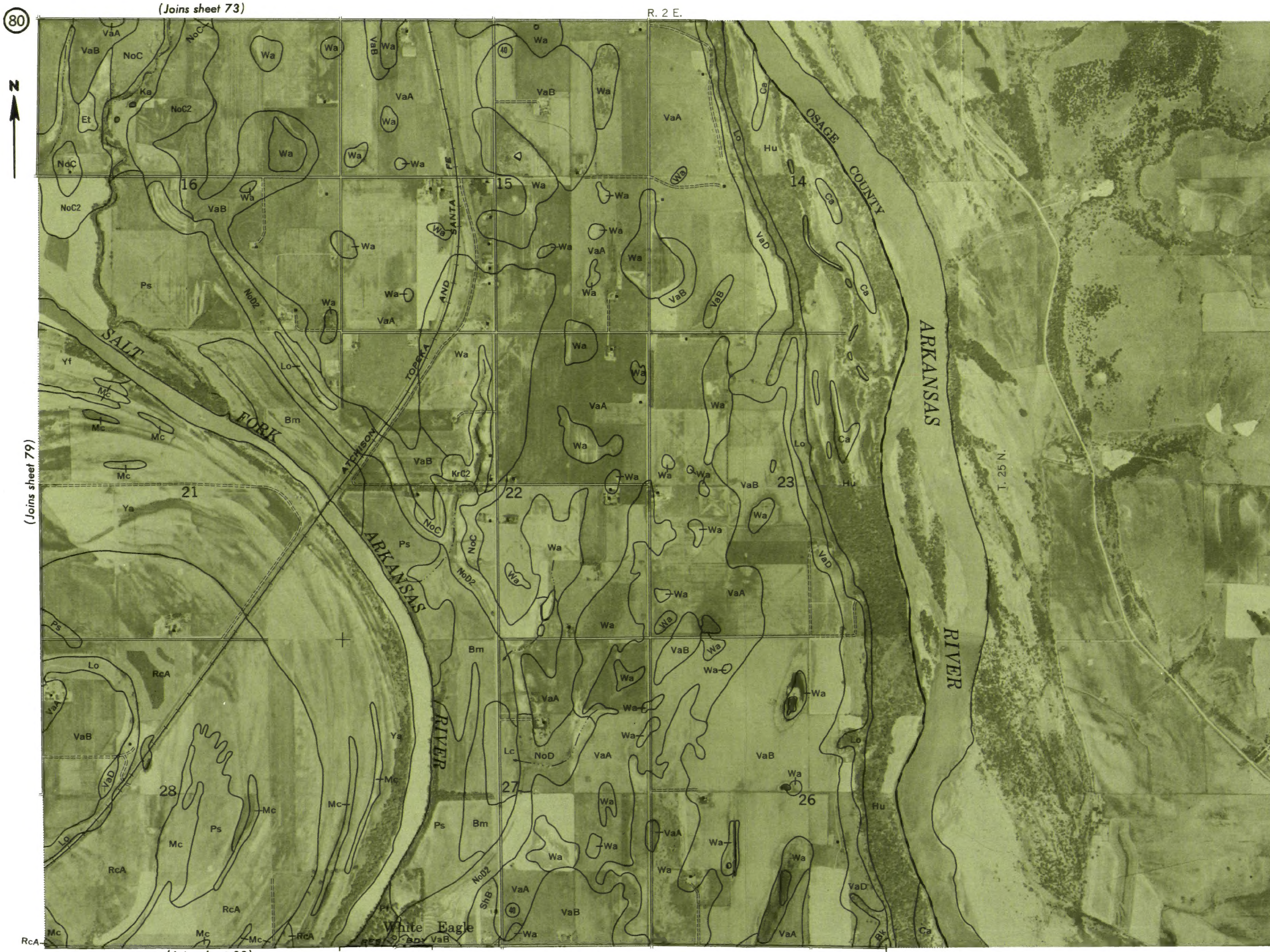

78
(Joins sheet 71)
NoC
R. 1 E.
N
Finley School
MERIDIAN
INDIAN
(Joins sheet 77)
(Joins sheet 79)
T. 25 N.
18
17
16
15
19
20
21
22
30
29
28
27
CHIKASKIA RIVER
SALT FORK
ARKANSAS RIVER
(Joins inset, sheet 82)
MaA
0
½
1 Mile
Scale 1:20000
0
5000 Feet

0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agriculture Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 79



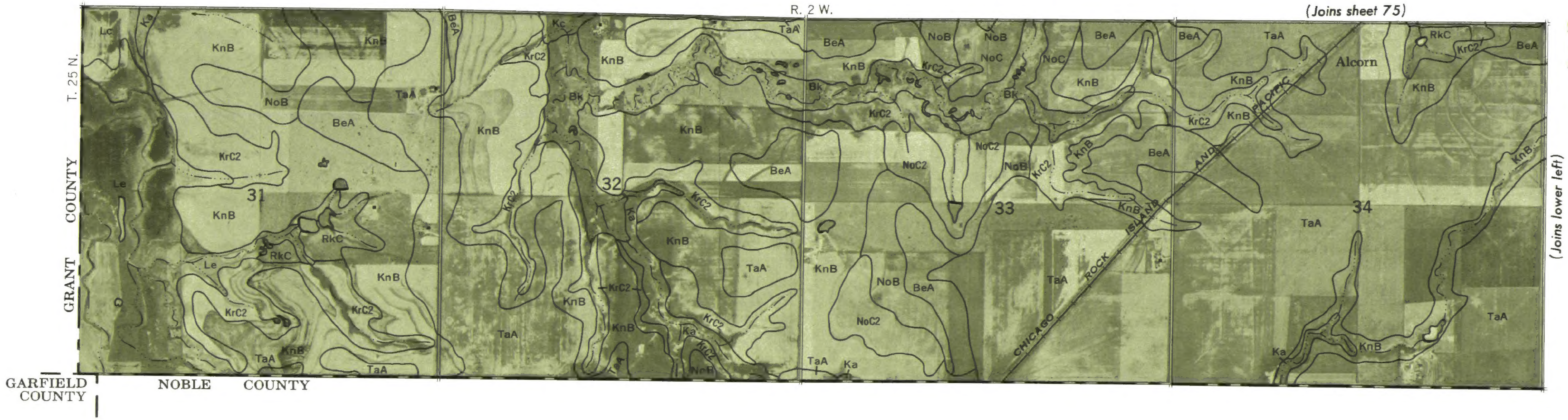
0 ½ 1 Mile Scale 1:20000 0 5000 Feet

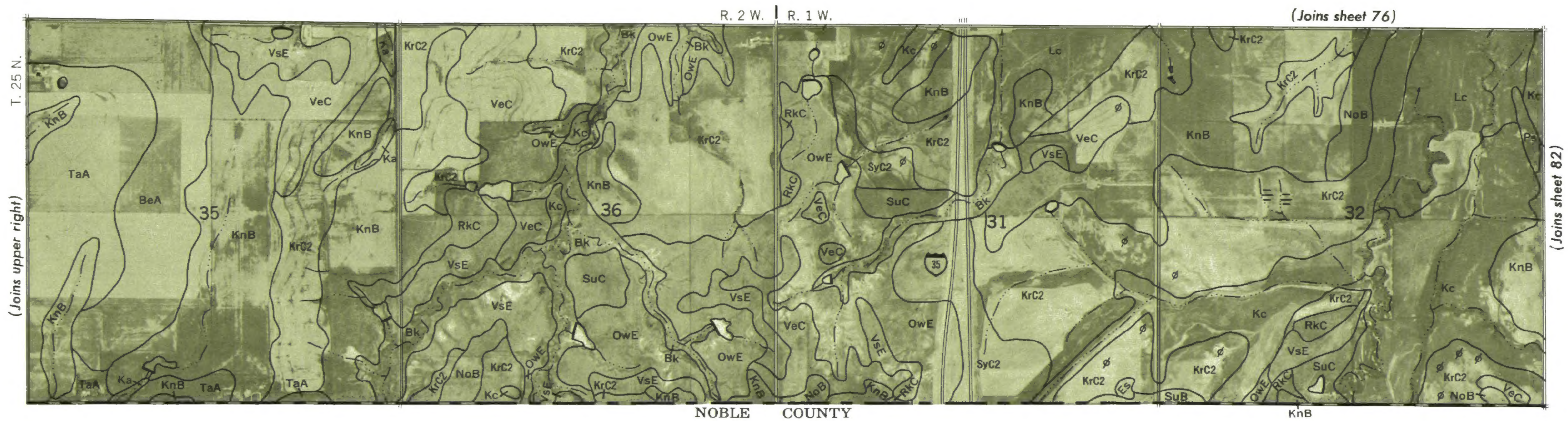
81

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

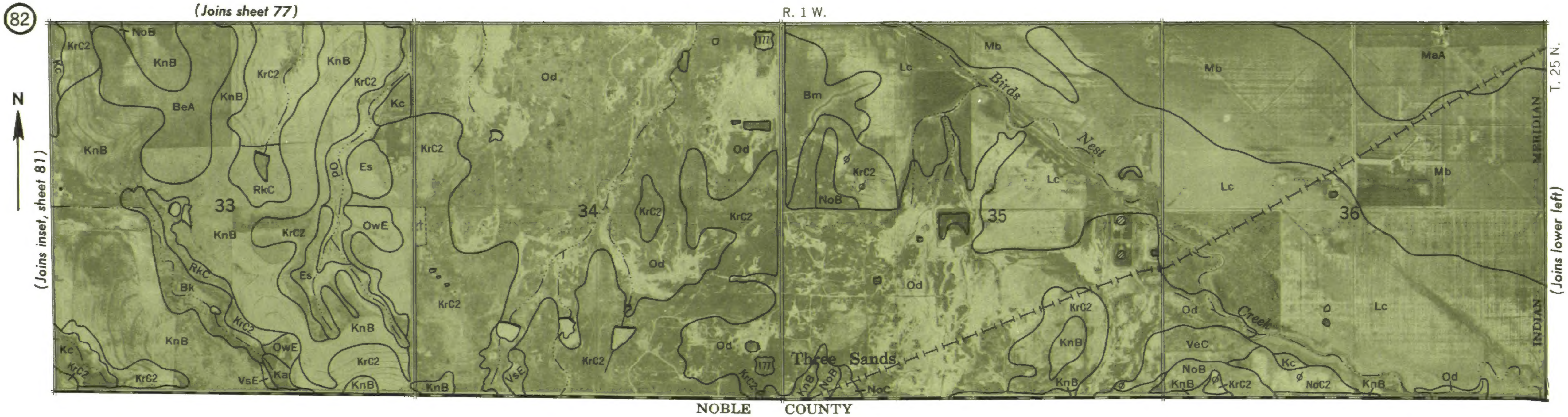
KAY COUNTY, OKLAHOMA NO. 81

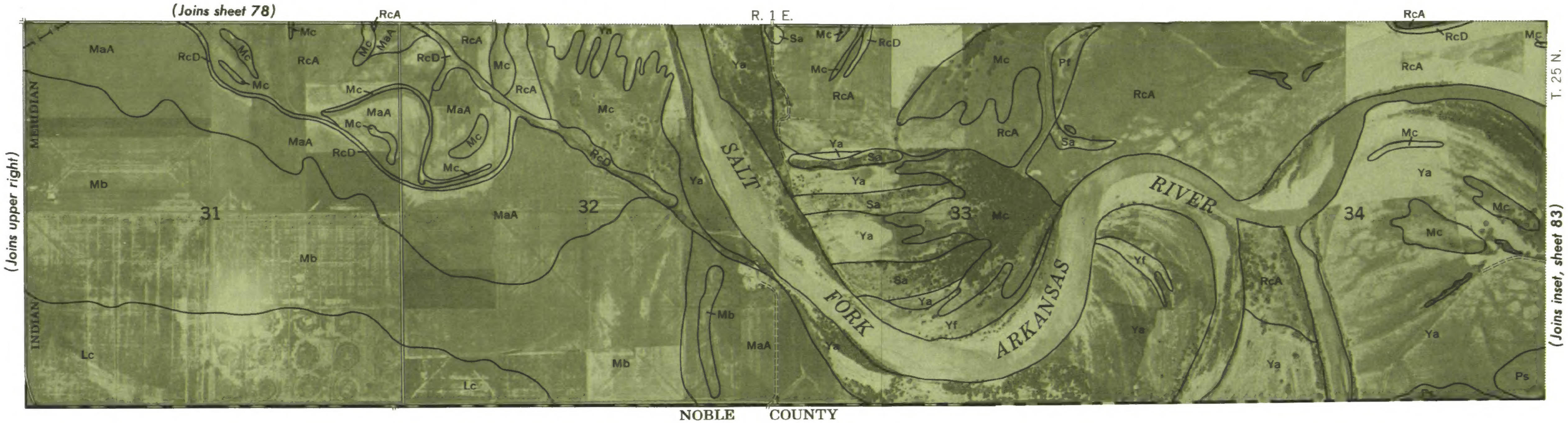




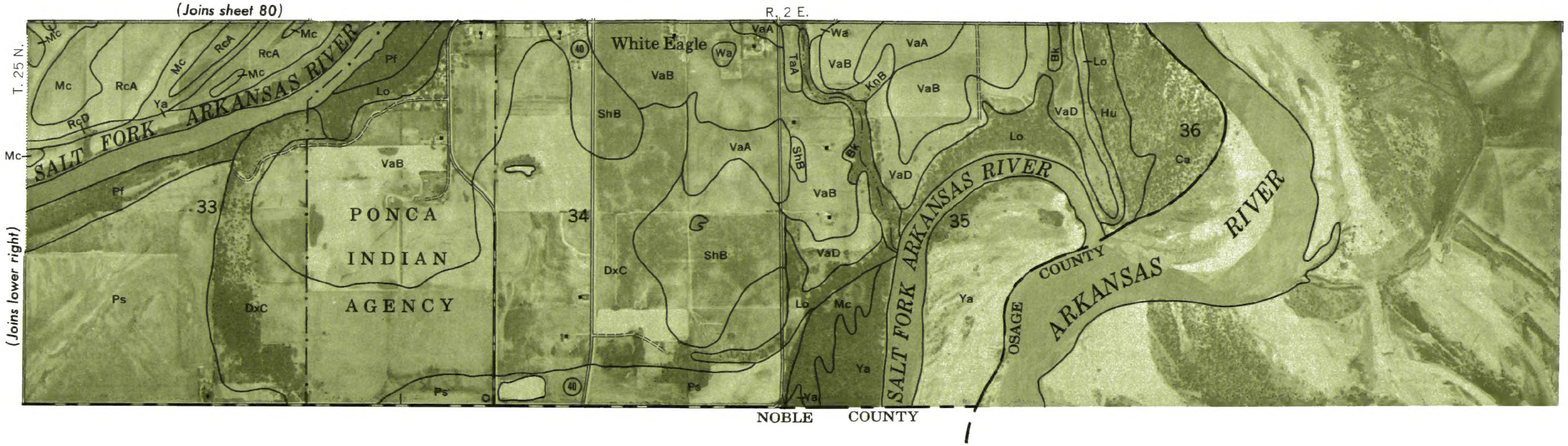
0 ½ 1 Mile Scale 1:20000 0 5000 Feet

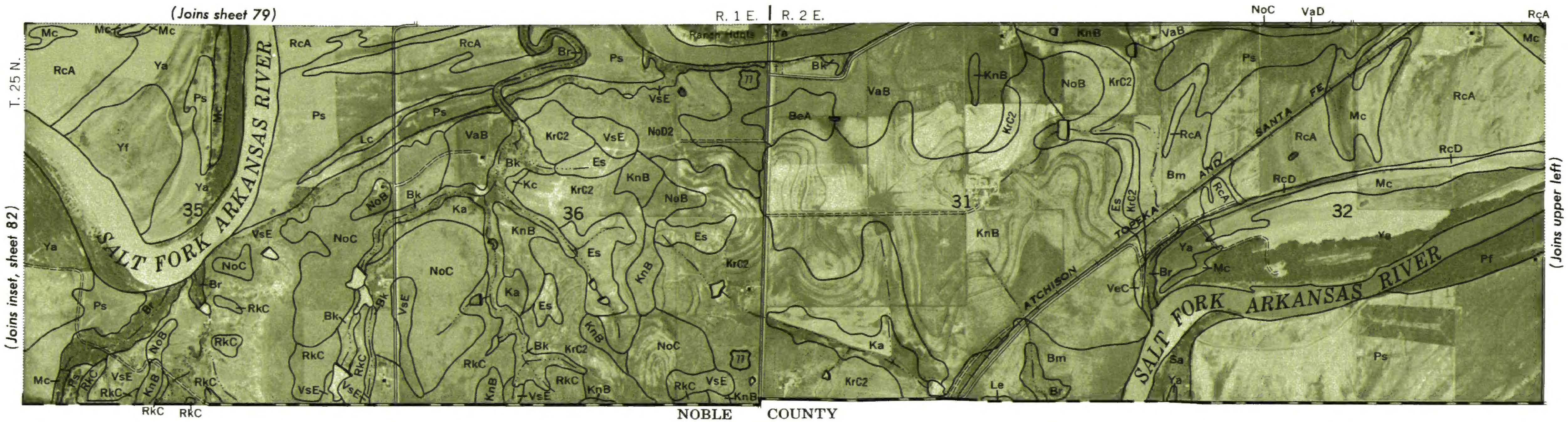
KAY COUNTY, OKLAHOMA — SHEET NUMBER 82





0 ½ 1 Mile Scale 1:20000 0 5000 Feet





0 ½ 1 Mile Scale 1:20000 0 5000 Feet

This map is one of a set compiled in 1966 as part of a soil survey by the Soil Conservation Service, United States Department of Agriculture, and the Oklahoma Agricultural Experiment Station.

Land division corners and numbers shown on this map are indefinite.

KAY COUNTY, OKLAHOMA NO. 83